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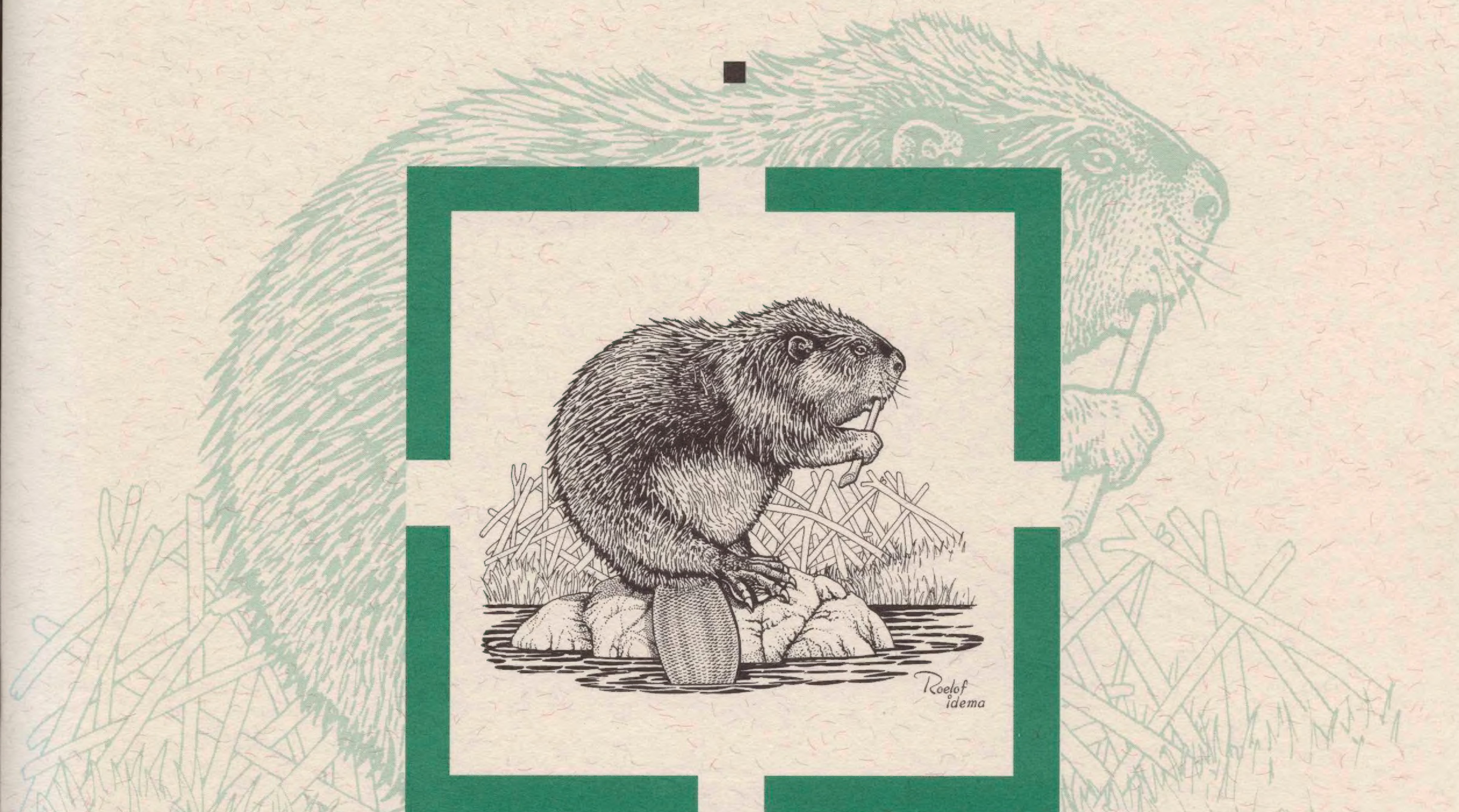
Global biodiversity

An International Forum on the Variety of Life on Earth...
research, conservation and wise use



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Editor's Notebook

Biodiversity Convention to come into force!

The Biodiversity Convention, the greatest convention on Earth, has just been ratified. Thirty states who were signatories of the Convention had to ratify it before it came into force. Mongolia became the thirtieth state to do so on 30 September 1993. This enables the Convention to come into force 90 days later on 29 December 1993. The first meeting of the Conference of the Parties, all those who signed the Convention at the Earth Summit, will occur before the end of 1994.

Canada was active in negotiating the Convention, and at a point when many nations were wavering about their committment because of the negative stance taken by the then U.S. administration, was the first nation to sign the completed Convention. The new American administration supports the Convention.

The Convention is arguably the most important international convention ever ratified. It deals with conserving biodiversity, the variety of life on earth, sustaining the ecological services that support the planet, global funding of conservation, sustainable development, the sharing of the benefits derived from biological resources, the transfer of technology, the research needed to fill in the gaps in knowledge on biodiversity, and education.

Properly supported by individuals, organizations, and states, the Convention will ensure the survival of life on Earth and humankind. It will help ensure that the South and states in transition will benefit from the conservation of biodiversity and the wise use of biological resources. It sends the message that human and other living beings are all part of the great 3.5 billion-year-old family of life, each deserving a place in the sun and a proportion of the Earth's surface.

Don E. McAllister

Don E. McAllister
Editor-in-Chief

The goals of Global biodiversity are to:

- *Publish articles, views and news on biodiversity*
- *Bridge the gaps between professional disciplines & the public*
- *Communicate information on Canadian & world biodiversity*
- *Express views on the needs & value of biodiversity research*
- *Enhance awareness of the role of biosystematic research & museum collections to conservation & wise use of biodiversity*
- *Discuss methods and philosophy of biodiversity conservation*
- *Review books and major articles on biodiversity*

News, views, articles for publication and books or papers for review should be sent to:

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It would be helpful if longer manuscripts were submitted in Word Perfect 5.1 or ASCII format on either 3 1/4" or 5 1/2" inch diskettes, with a hard copy printout to show italics, etc., if in ASCII.

Cover image is an American beaver,
Castor canadensis

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The flow of life

A summary of a talk given by Maximo T. Kalaw, Jr.
Haribon Foundation for Conservation of Natural Resources of Manila at the World Inter-Action 20th Anniversary Celebrations,
23rd October 1992

Prepared by Marilyn Hart, World Inter-Action Member

World Inter-Action members and guests were privileged to hear, first hand, the philosophies and experiences of Maximo T. Kalaw, Jr., a key figure in the Philippine environmental movement and a respected participant in the Earth Summit in Rio. In recognition of his contribution to the Earth Summit he has recently been appointed to the Earth Council. Hopefully, his sensitive and holistic understanding of the true meaning of sustainable economic and environmental development will have some bearing on future global actions by all levels of government.

Maximo traced the growth of his own involvement in environmental issues in the Philippines, which began with a simple bird watching society in 1972, to the establishment today of a research-based environmental foundation, and the formation of the Green Forum, a strong coalition of environmental action groups in his country, of which he is President. His work deals with the urgent need to conserve natural resource systems, and at the same time recognizes the reality of poverty in his country and the need for some form of meaningful development–sustainable development.

His messages were clear, and drew for illustration from the voices of the Philippine people. First, he said, before dealing with any type of development, the sacredness and inter-connectedness of life on Earth must be respected and understood by all. "The foreigners who came to these islands placed God on top of the mountain. We must bring God down into the streams, the fields, and the forests." Sustainable development can only succeed when individuals and communities have a clear understanding of their own spirituality. These principles of spirituality have been embodied in the Philippines' manifesto on development.

> ▪ *The indigenous cultures of the peoples place great value and personal status on actions that pass the Earth's bounty on to the community and so enrich the flow of life for all.*

And what is this thing called development? Development should not be judged by the Western economic model, reflected in "growth," or in other words, by the accumulation of goods and wealth for the individual. In the Philippines there is a word *hanap-buhay*, which translates as the "flow of life." The indigenous cultures of the peoples place great value and personal status on actions that pass the Earth's bounty on to the community and so enrich the flow of life for all. Thus development should strive to enhance the flow of life, realize the potential of something, and use the resources of the Earth to create a fuller, greater, better state of being, not a depleted state of being. This concept of the "flow of life" has also been incorporated into their manifesto on development.

A sense of community purpose is, of course, paramount in the Philippine development process, an understanding which has long been recognized by non-governmental agencies such as World Inter-Action. Appropriate development strategies must be orchestrated *by* the people, not *for* the people. To this end, Maximo felt that at least the underlying philosophies of northern based NGOs were supportive of his call for local community action. His message, however, was a plea for NGOs to become more united in their efforts, and for them to change their focus; to become more involved in pressing for policy changes at a macro world level; to look at building changed foreign policies and new trade agreements; to think of the implications of direct technology transfer; to lobby for the restructuring of foreign debt. Sending aid workers into the foreign field to "help" was no answer at all.

▪ *Appropriate development strategies must be orchestrated* ***by*** *the people, not* ***for*** *the people.*

And so how might all of us help? Maximo's strongest message, in conclusion, was that we should look into our own society and our own lives. We must stop the hypocrisy of interfering in the affairs of Third World nations, while ignoring our own excessive life style and consumption habits, and continuing with our existing economic systems. To a large extent the problems in the "South" are a result of societal values of the "North," and these must be changed in our communities. Of course, this type of change is not easy to achieve. We must try and learn from the cultures of other people. There must be reciprocity of ideas between nations, not an imposition of ideas from one country to another. Countries from the North and South must have a common mission, or the goal of a globally sustainable environment is nonsense. These were the messages that were gently but powerfully delivered to us.

▪ *There must be reciprocity of ideas between nations, not an imposition of ideas from one country to another.*

In the Philippines, with the guidance of people such as Maximo Kalaw, new principles of development are being voiced. These principles do not separate spirit and matter, ecology and economics, society and nature, and community and state. This understanding must be realized at a global level, and we at World Inter-Action should consider carefully how we might contribute to this understanding, and how we will respond to the other messages of Maximo Kalaw, Jr.

The Canadian Centre for Biodiversity gratefully acknowledges permission from Maximo Kalaw, Jr. and World Inter-Action to reproduce the above text from their Twentieth Anniversary Retrospective Newsletter.

Towards a biodiversity strategy for Canada

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Canada, one of the earliest signatories and ratifiers of the Convention on Biodiversity, has begun a cooperative process of developing a national biodiversity strategy, which provides for a variety of participation. The process should be of interest to Canadians as well as to those in other nations, which are also developing their own biodiversity strategies.

Editor-in-Chief

Transforming the diplomatic, legal language of the United Nations Convention on Biological Diversity into a concrete government action plan is an unique challenge. A small group of federal, provincial, and territorial officials are now meeting this challenge as they prepare a Canadian Biodiversity Strategy. Armed with a mandate to develop the national strategy by November 1994, the Federal-Provincial-Territorial Biodiversity Working Group is in the early stages of developing strategic recommendations for the wide range of obligations that Canada accepted when the Prime Minister ratified the Convention last December.

The Biodiversity Convention stands as one of the major successes of the United Nations Conference on the Environment and Development. Negotiated by an intergovernmental committee, the Convention has three objectives: the conservation of biological diversity, the sustainable use of the Earth's biological resources, and the fair and equitable sharing of the benefits arising from the use of the world's genetic resources. These objectives illustrate the dual nature of the Convention. It is not only about preserving global biodiversity, it is also about sustainable use and sustainable development, based on biological resources. It is about using the Earth's biological resources wisely for economic development purposes and about supporting the growth of developing countries through the wise use of their resources.

On 30 September 1993 Mongolia became the 30th country to ratify the Convention. Ninety days later, on 29 December 1993, the Covention will come into force and the first meeting of the Conference of the Parties will occur before the end of 1994.

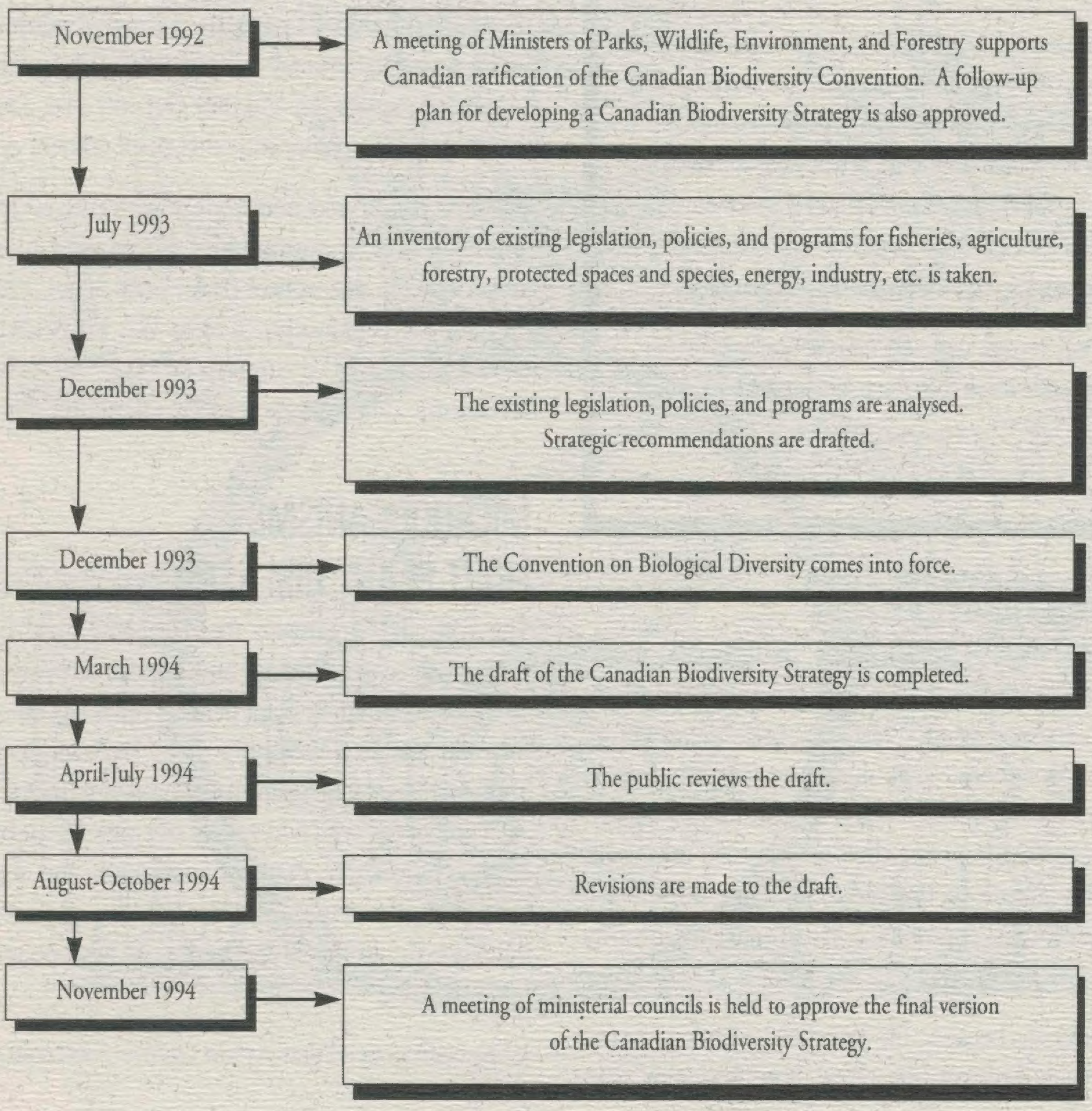
To reach the objectives laid out in Article 1 of the Convention, a series of measures, which each country is required to implement, is outlined. These measures range from the establishment and management of protected areas for the conservation of biodiversity to the adoption of social and economic incentive measures to encourage the conservation and sustainable use of biodiversity. Some of the measures described in the Convention apply to each country's political, social, and economic policies internally, while others require international cooperation on a bilateral or multilateral basis. Developed countries, such as Canada, are required to provide financial assistance to developing countries to assist them in their efforts to conserve their biodiversity. Unquestionably, the key measure is the requirement that countries develop a national biodiversity strategy, enabling other conservation and sustainable use measures to be implemented in an appropriate national context and priority.

The Canadian Biodiversity Strategy is being developed to fulfil the terms of Article 6 of the Biodiversity Convention and to set the state for Canadian compliance with all the Convention's articles. The process and schedule for producing the Strategy has been laid out in a plan approved by the federal, provincial, and territorial ministers of the respective environment, parks, wildlife, and forestry departments. According to the plan, the joint working group is responsible for producing the Strategy, with the ongoing advice of a Biodiversity Convention Advisory Group (BCAG). The BCAG is composed of representatives of national business, industry, environmental, conservation, and other stakeholder groups. Working together, the government representatives and the advisory group are developing recommendations for the final approval of the federal, provincial, and territorial governments.

Given the wide scope of the Convention, the Strategy will, of necessity, be comprehensive and cross-sectoral. Members of the government working group and the BCAG recognize that the conservation of biological diversity is a long-term goal requiring a variety of approaches. Above all, they recognize that biodiversity is not something found only in national parks, gene banks, and tropical rainforests. Instead biodiversity is found in the working landscape of Canada–the forests, farms, and fishing grounds that generate much of the country's wealth–as well as in protected areas. As such, they also recognize that Canada must develop programs and policies to encourage conservation in all sectors of the economy.

While the federal, provincial, and territorial action plans relating to the Strategy will be independent, the Strategy is being developed in a cooperative way. This cooperative approach, including cooperation between governments and the private sector, is a continuation of the effective partnerships that were struck during the negotiations for the Convention. Such cooperation, particularly with the resource sectors of the economy, will be necessary to tackle the complexities of conserving Canada's biodiversity.

The draft Strategy will be released for public review in March 1994 with the goal of completing the Strategy by November 1994. Specific federal, provincial, and territorial action plans will then be developed based on the recommendations contained in the Strategy.


November 1992
A meeting of Ministers of Parks, Wildlife, Environment, and Forestry supports Canadian ratification of the Canadian Biodiversity Convention. A follow-up plan for developing a Canadian Biodiversity Strategy is also approved.
July 1993
An inventory of existing legislation, policies, and programs for fisheries, agriculture, forestry, protected spaces and species, energy, industry, etc. is taken.
December 1993
The existing legislation, policies, and programs are analysed. Strategic recommendations are drafted.
December 1993
The Convention on Biological Diversity comes into force.
March 1994
The draft of the Canadian Biodiversity Strategy is completed.
April-July 1994
The public reviews the draft.
August-October 1994
Revisions are made to the draft.
November 1994
A meeting of ministerial councils is held to approve the final version of the Canadian Biodiversity Strategy.

This flow chart shows the steps and the timelines involved as Canada works to develop a Biodiversity Strategy.

We can't live without them–Soil microorganisms

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Microorganisms are often regarded as harmful organisms. Study shows they play a number of intricate beneficial roles in the soil, helping sustain its health and productivity and also that of the crops and wild plants that depend on it. Wise agricultural practices will take into account the rich variety of tiny life forms in the soil.

Bacteria and fungi are important groups of soil microorganisms. It is estimated that there are 3 million species of bacteria in soils and other environments, but only 4,000 species have been described so far. Soil and other kinds of fungi are estimated to include over 1.5 million species, only 70,000 of which have been described. So less than 2% of the species in these two groups have been discovered, scientifically named, and classified.

A voyage on a microscopic spaceship into the world of the soil would make ***Jurassic Park*** *look like a kindergarten picnic!*

Editor-in-Chief

INTRODUCTION

Most of the small organisms–algae, bacteria, and fungi–are mostly unnoticed and ignored in our present approach to biodiversity research and conservation. There are exceptions. The microorganisms that cause disease are relatively well-studied for medical, veterinary, and crop disease purposes. But even disease organisms, which play a role in the reduction of a population overload and thus, contribute to sustaining the diversity of ecosystems are not that well studied.

It is unfortunate because the beneficial microorganisms, the backstage directors, are often more important than the plants, the star performers, which produce foodstuffs and fibre for humans. Behind the scenes, they are continually playing a vital role in the production of oxygen, the banking of carbon dioxide, and mineralization. They are also paramount in the breakdown of wastes and deceased organisms, which is necessary for the recycling of nutrients.

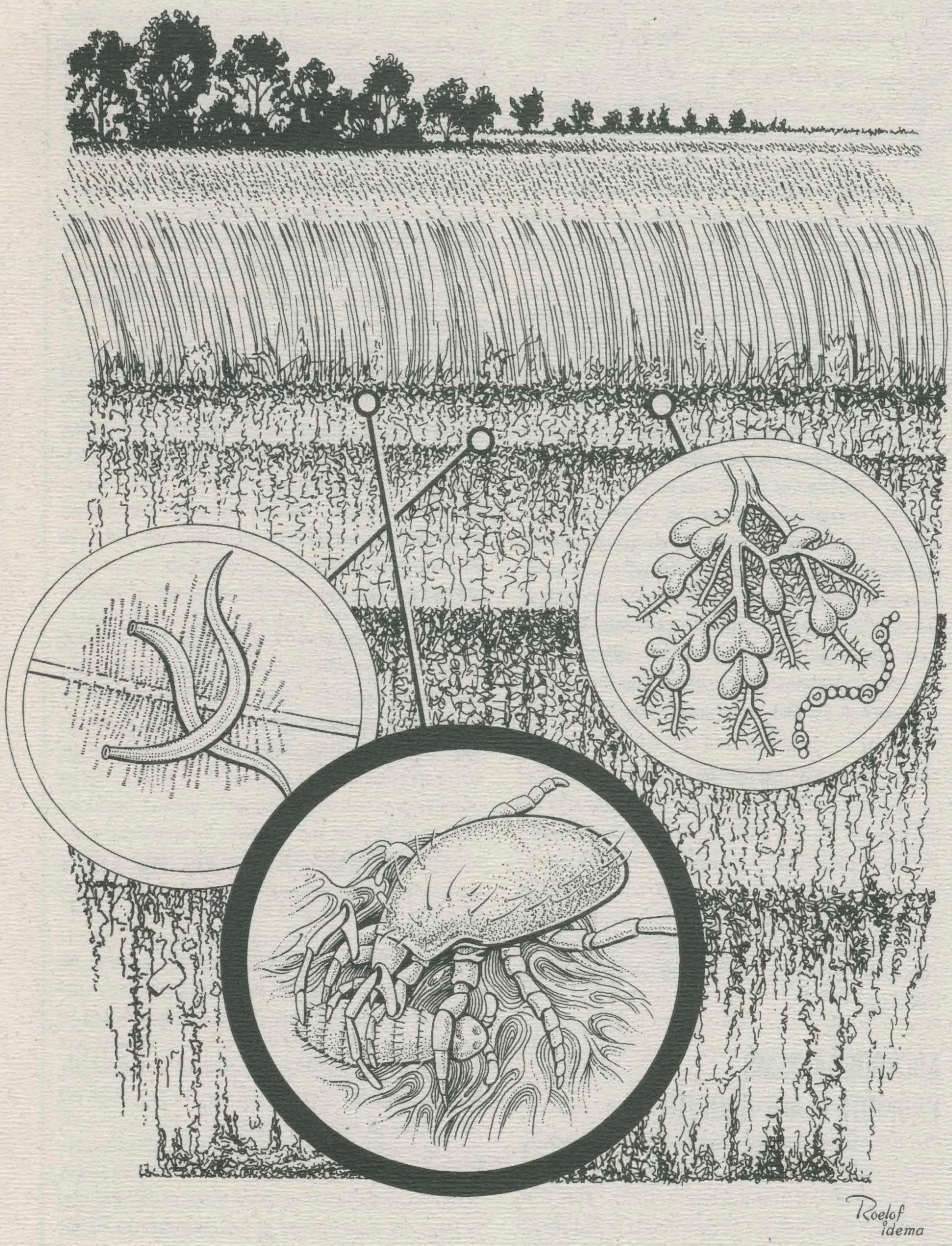
There are several ways soil organisms enhance plant growth and health. They may prevent invasion of disease microbes into the plant through interference or antibiotic action; they may aid in the direct nutrition of the plant through its roots by supplying nutrients and using wastes; they may supply "grazing" or a nutrient supply for nematodes, and they certainly play a vital role in nitrogen, phosphate, and other plant nutrient cycles.

Bacteria, fungi, and nematodes are found to be more abundant in soils surrounding the roots of plants, the area called the rhizosphere (Harley and Smith, 1983), and the intimate conjunction of roots and fungi lead to the development of a beneficial system known as mycorrhiza, called mycos for short (McAllister, 1993).

MICROORGANISMS FIGHT PLANT DISEASES

The soil microorganisms that suppress plant diseases have evolved with plants and appear to be a primary factor in determining plant health. (Man has tapped into this capacity in developing drugs such as penicillin.) Therefore, microorganisms have a direct influence on the selection of the type and variety of crop to be grown, the rotation procedures, pesticide application, and in general, land use. In return, these agricultural procedures influence the health of the beneficial microorganisms in the soil.

It has been noticed that certain undeveloped soils, when



In the soil, all around the globe, microorganisms are at work: producing oxygen, banking carbon dioxide, aiding in mineralization, breaking down wastes, and recycling nutrients. Unfortunately, most microorganisms are ignored in the present approach to biodiversity research and conservation. Is it not time to understand and appreciate the tremendous value of these microscopic creatures–and ensure that they are protected?

planted with a crop for the first time, prevent the development of specific soil-borne diseases. Under such circumstances, the soil is called *disease-suppressive.* This characteristic is associated with certain physical and chemical characteristics that affect the microbiology of the soil and produce a natural suppressive capacity. This is not usually affected by cropping practices.

Suppressiveness can also be induced. When it is, this valuable soil characteristic becomes evident after several crop rotations. And in fact, inducing suppressiveness is a prerequisite for the practice of monoculture with a susceptible crop. Although the value of suppressive soil cannot be easily measured monetarily, due to complex biotic interplay, it has been shown that such soils do have an impressive effect on crop yields.

In contrast to suppressive soils, there are *conducive soils* in which certain soil-borne diseases occur to a significant degree. Even here the full potential of soil-borne pathogens, or killer microorganisms, is not realized. Studying the disease called "Take-all" of wheat, caused by a fungus, *Gaeumannomyces graminis* var. *tritici,* shows the powerful effect of introducing suppressiveness into the soil. In conducive soil there is a 33% decrease in grain yield, but with the onset of induced suppression, only 9% is lost. Fusarium wilt of muskmelons is a severe disease in the regions of Cavaillon and Carpentras in France while in nearby Chateauremard little disease is seen. The fungus is present in all three regions, and so, the disease levels are most likely due to the soil–conducive in the first two regions, suppressive in the third.

Despite some work that has been done in this field and the identification of several forms of suppressiveness, the mechanisms are still unclear. In some experiments, extracts of the soil aided in suppressiveness, as did the pH (or acidity) of the soil. It appears, however, that no matter how much other factors contribute towards suppressiveness, biological components are essential. Treatments that destroy native microflora render the soil conducive.

MICROORGANISMS PROMOTE PLANT GROWTH

The bacteria that colonize roots, and do it aggressively, have been given the names of *rhizobacteria* or plant-growth-promoting rhizobacteria (PGPR). This is to distinguish them from soil bacteria found in and around the root area. The latter organisms do not colonize roots or do not do so in an aggressive manner. They are, for the most part, transients. Most of the beneficial rhizobacteria belong to the *Pseudomonas* group.

Only 2-5% of the bacteria isolated from plant roots have the ability to aggressively colonize roots and to increase plant growth. This fact should surely be taken into account in the production of seeds for agricultural purposes. Most seeds are "pelleted" or coated with a variety of compounds, such as fertilizer, and enhanced pelleting procedures could be developed so a higher percentage of PGPR survive the inoculation and planting processes. But there are still problems to iron out: some strains of bacteria are effective in a particular soil type, but not in others; other soil bacteria can and do colonize the coating mixture, thus interfering with the viability of the PGPR.

Promoting plant growth appears to be related to reducing infection and allowing the colonization by specific bacteria or fungi. In one set of laboratory experiments, the wild strains of PGPR reduced fungal infection by 23-64% and bacterial infection by 25-93%. There was no difference, however, between the general microflora found near the root surfaces of control plants and those inoculated with antibiosis negative mutants, mutant types of PGPR that have lost their antibiotic-producing ability.

But in the lab, less than 5% of rhizobacteria that exhibit antibiosis, or the ability to fight infection, actually affect plant growth positively. Why is this? It is undoubtedly due to other important characteristics of the organisms such as root-colonizing ability. The organisms that are solely antibiotic in effect may not all be helpful: 8-15% of antibiotic-producing strains can be harmful, producing stunting of the plant and root loss. It seems that the key to promoting growth is selecting rhizobacteria with a combination of characteristics of which antibiosis is just one.

Matters are further complicated by other factors. We know that PGPR markedly affect the composition and root colonization by fungi. While the changes can be positive, they are harmful in some cases, allowing root infection by the fungal species *Pythium* and *Fusarium.* Also, some strains of PGPR that promote growth do not show antibiosis in the lab.

Then there are strains of PGPR that are toxic to plants. They are called deleterious rhizobacteria or DR. Included in these are many species of the *Enterobacteracea,* the gram negative rod bacteria. Because of their toxin production they do not have to be parasitic *per se* in order to cause disease. Undoubtedly, they are an important group of DR and have been overlooked because of their subtle method of attack.

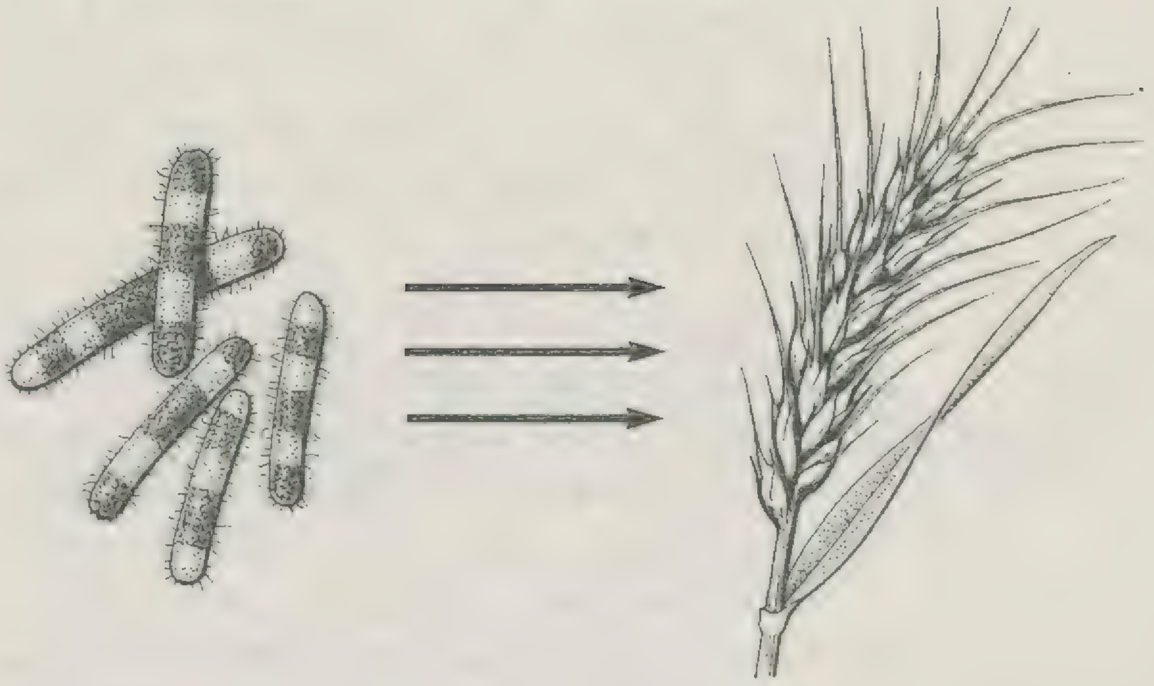
While the ability of PGPR to produce antibiotics is a large key to their success, their ability to collect iron is also important. Iron is essential for life and is involved in the processes of life such as oxygen transport (haemoglobin in the blood), photosynthesis, and energy conversion processes. Most animals take iron with the food they digest, but mircroorganisms must extract it from more inacessible sources such as insoluble hyrdroxides. In order to do this, some bacteria have evolved their own iron carriers called siderophores. They secrete these molecules into their surroundings to bind to iron and then, by means of protein receptors on their surfaces, transport the iron internally where it is released and used. Literally, they digest the iron–usually unaccessible to plants–and bring it to the plant roots. When they die (which they do often!), the iron is released and is now in a form the plant can use.

It is the combination of the production of "antibiotics" and an efficient iron-collecting system that enable PGPR to combat other harmful bacteria. But no matter how successful they are in doing so, they will not promote plant growth unless they have the prerequisite for aggressive colonization. While the most likely explanation of this genetic expression, a great deal more work must be done on this subject before firm conclusions can be drawn. Nevertheless, it is clear that soil microorganisms are important in sustaining healthy productive crops and wild plants.

FUNGI AND ROOTS: THE TIES THAT BIND

The combination of the soil fungi and roots of plants is known as *mycorrhiza*, or *mycos* for short. This is a symbiotic or mutually beneficial relationship whereby two or more organisms join forces and flourish. Separately, each partner would not fare as well.

The best known example of a symbiotic relationship is the lichen. In the lichen relationship the contribution of the two partners of algae and fungi has been well documented. The fungus cannot synthesize its own energy components, so it obtains these from the algae during their process of photosynthesis. The algae, on the other hand, are protected by the surrounding fungal mat of threads and from them, receive essential inorganic nutrients necessary for algal growth.



By fighting infection and recycling iron into a digestible form for plants, the aggressive rhizobacteria promote plant growth.

> ▪ *85% of the Earth's higher plants form a mutually beneficial partnership with fungal mycos.*

In a similar way, fungi also enter into a symbiotic relationship with other plants in which each partner receives certain benefits. However, unlike the algae-fungi partnership in lichen, the myco-plant relationship is not that well understood. In addition, it appears to greatly vary depending on the fungus and the plant involved. Many of the basic facts of this relationship remain hidden. All of them, however, involve fungal linkages with the roots of plants, particularly trees, orchids, and other saprophytes (plants that live on decaying material). Altogether 85% of the Earth's vascular plants form mycos with fungi. The union is found most often in soils that are rich in humus and low in nutrients. Under these conditions the linkages are absolutely necessary for some species of orchids and highly beneficial for the growth of trees, especially pines. They are also highly beneficial for the growth of coffee trees and the rich flora of the rain forests.

Myco-fungi include a wide variety of species that form symbiotic relationships with the roots of higher plants. There are two main forms of this partnership: external (*ectotrophic*) and internal (*endotrophic*). In the external mycos partnership, the mycos form a sheath around the fine roots of trees and, in addition, send additional filaments into the surrounding soil. A great many of these fungi belong to the groups of *Basidomycetes*, commonly recognized as forest mushrooms. These mushrooms are the fruiting bodies of external mycos. External mycos are most common in temperate climates. A root with mycos can be recognized by the large number of thick, short, lateral roots, abundant root branching, and in some of them, a sheath of mycos. In some cases, particularly in pine trees, root hairs are lacking. These specialized root cells for absorption are replaced by myco filaments.

The mycos are most important in the transfer of soil nutrients, which tend to have a low diffusion rate. For instance, they contribute greatly to the transfer of phosphate to the plant. Phosphate is an essential ion for plant growth but it is particularly immobile in most soils. Here the mycos' filaments act as pipelines, and the condensation and holding of nitrogen and other nutrients also takes place. With an increase in phosphate absorption, the uptake of other nutrients usually increases, forming one example of nutrient balance (Bowen and Smith, 1981). The net result is higher rates of growth for the plant. Indeed many species of pine will not grow without mycos or will grow poorly. The re-establishment of forest growth following exploitation by clear-cutting or by mining is not effective without special efforts being taken to establish the mycos relationship (Reeves *et al*, 1979). They are of extreme importance in infertile sites.

Most tropical trees appear to have internal mycos. In this situation the fungal filaments do not form a sheath around the root but actually penetrate the cells of the root cortex. They are also essential for the growth of orchids. Here one of the main functions of the mycos is to supply sugars, which the tiny seeds must otherwise obtain from decomposing organic matter. Some orchids become independent of the mycos when they begin photosynthesis in excess of respiration; the non-green orchids are dependent for life. In a similar fashion, higher plants that lack chlorophyll and live on decaying material depend on mycos for their survival. Basically the fungus takes sugars and growth substances from the roots and passes phosphates and minerals from the soil to the roots.

The combination of soil fungi and the roots of a plant is known as as mycorrhiza or mycos, for short. The mycos relationship contributes greatly to the transfer of soil nutrients to the plant.

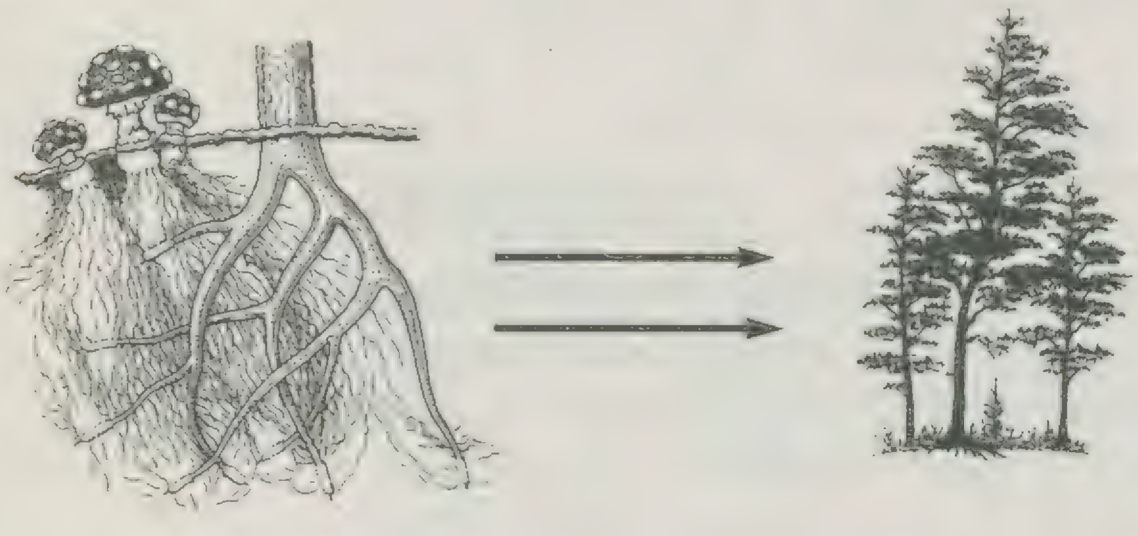
In the tropical rain forests of South America the fine feeder roots occur mainly in the well-aerated upper layer of humus that is not water-logged. Below this layer are poorly developed, tropical soils comprised of sands or clays. The internal mycos are found in close association with these feeder roots, which lie in layers between the debris of the forests' floors.

When the forest is destroyed by cutting, burning, and cropping, the mycos are destroyed, too. Such areas rapidly become overgrown with poor brush due to the leaching and washing of soluble minerals from the soil; soluble minerals that the mycos had formerly transferred to the climax forest.

The tropical forest system is probably one of direct mineral recycling. Here the minerals are tied up in dead branches or leaves, and then they are transferred to roots through the mycos. In such a system very little mineral is solubilized and moved into the soil. In addition these mycos are able to digest cellulose and lignin and break down woody debris on the forest floor (Went and Stark, 1968).

When we view a lush tropical rain forest, many of us assume that the soil beneath must be equally rich. This is not so, and this fact can be seen by the results following the cutting, burning, and cropping of trees. This effectively removes the organic materials and allows minerals to wash off. The land quickly starts to yield poor crops, then it is abandoned, and it rapidly becomes overgrown with poor second growth or scrub. Such a situation occurs due to a lack of minerals and mycos.

Fungi are also beneficial in desert climates where they add to the cohesiveness of soil. They are also the main litter decomposers and comprise the largest biomass or the total weight of living material.



BACTERIA, FUNGI, AND MICROFLORAL GRAZERS

Bacteria, fungi, and nematode (round worms) grazers are another soil ecosystem involving microorganisms and flora. The grazers can also be protozoa (single-celled animals) and microarthropods (tiny soil insects and mites). The grazing of microorganisms in the areas around plants results in increased plant growth, increased nitrogen uptake by plants, decreased or increased bacterial populations, increased nitrogen and phosphorus mineralization, increased carbon dioxide evolution, and increased substrate utilization (Ingham *et al*, 1985). They occur most frequently in the rhizosphere, soil that is intimately connected with plant roots.

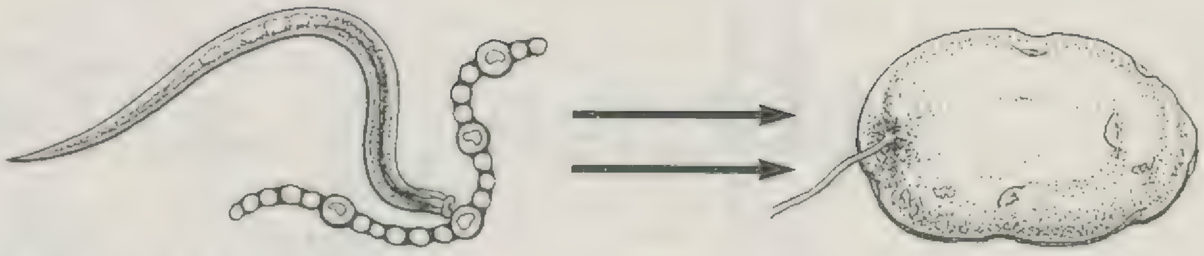
Plants that were grown in soils where bacteria grazed grew faster, and initially at least, took up more nitrogen than plants grown in soil with just the bacterial "pasture." The better growth patterns are due to increased nitrogen mineralization by bacteria, the excretion of NH4-N by nematodes, and greater initial exploitation of soil by plant roots. The nematodes that fed on fungi did not lead to any increase in these parameters, probably due to the fact that the nitrogen mineralized by the fungus alone was sufficient for plant growth. However, the phosphorus found in shoots of plants was greater after the fungal- and bacterial-feeding nematodes had been allowed to graze.

The additional mineralization that occurs during microbial grazing may be of use during periods of plant growth, which happen during short periods of ideal conditions. Or the additional mineralization may be of importance to plants when mineralization by microflora alone is insufficient to meet the plants' requirements.

CONCLUSION

When considering biodiversity, the whole area of microbial interaction with plant growth, whether it is regarding herbaceous plants or trees, commercial or wild, generally has been neglected. Note that less than 2% of the microbial species have been described by taxonomists! This is despite the fact that soil microorganisms are the starting machines of nutrient cycling or the end of it, depending upon one's point of view.

With the advent of managed forests, clear-cutting and strip mining, standing dead trees, fallen logs and forest floor detritus are rarely retained. Yet these provide the essential elements for many organisms and processes within forest ecosystems. Forest management activities have tended to eliminate these sources and the nitrogen-fixing species of plants in such genera as *Caenothus* (Thimbleberry) and *Alnus* (alders). This is done to eliminate competition from non-crop species and to speed the development of a closed canopy of crop trees.



When microorganisms such as this nematode graze on the microflora in the soil, they improve the nutrient cycle for the plants grown in that soil.

In addition to the concern of sustainable forestry practices, the forest soil quality must be considered. Efforts must be made to retain logging slash so as to replenish soil nutrients, retain beneficial microorganisms, and to prevent erosion (McAllister, 1993b). Intensive tree farming also entails the greater use of herbicides, insecticides, and fertilizer, which have a marked effect on soil microflora.

While the mycos and their plant companions may not be as charismatic as some megafauna, such as the panda or seal, they are probably of more use in the initiation and maintenance of ecosystems, and, *in toto*, the biosphere.

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Listening to and identifying wildlife using computers

An in-depth look at the automated intelligent monitoring system (AIMS).

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Monitoring the calls of wildlife is a useful method of identifying which species are present at a site and estimating their numbers. Information from auditory monitoring can be used for baseline surveys, impact assessment, rapid assessment process (RAP), as well as research on behaviour, life history, and other aspects of biology. However, the traditional monitoring of calls by individuals is limited by the availability of experts, the amount of time available, and the fact that some species call at dusk, others at night, or still others at dawn. The automated intelligent monitoring system (AIMS) described in this article overcomes many of these problems and offers additional advantages.

Editor-in-Chief

INTRODUCTION

In recent years, habitat destruction, over-harvesting, and pollution have led to an alarming loss of much of the world's biological diversity. Because the current decline in biodiversity is largely the result of human activity, the United Nations Conference on Environment and Development (UNCED) has produced a set of recommendations that, in part, are intended to improve the conservation of biological diversity (Convention on Biological Diversity and Agenda 21, Chapter 15). This agenda on "Biodiversity" was recently signed by Canada, the U.S.A. and many other nations; 30 nations have ratified the convention to date, and it will come into force at the end of 1993.

Fragmentation tends to reduce the biodiversity of forest and wetland ecosystems. Over the last twenty years, activities associated with transmission corridors and housing developments have resulted in some fragmentation of forests and wetlands in southern Ontario (Hounsell 1993). Although the actual impacts of the fragmentation have not been fully evaluated yet, preliminary investigations indicate that adverse impacts may have occurred. Habitat fragmentation associated with human activities can lead to the loss of diversity within species by hindering the natural migration patterns of particular populations to traditional breeding grounds. Fragmentation has other effects, too. For instance, the access of parasitic Cowbirds to the nests of forest-dwelling birds has increased, resulting in lowered survival of forest bird nestlings and therefore, contributing to declining or disappearing populations.

A better means of gathering quantities of data could help monitor the impacts of fragmentation and help find means of reducing losses in biodiversity. Could computers supplement scientists in the field? Two years ago, Ontario Hydro decided to find out by developing a prototype....

AUTOMATED INTELLIGENT MONITORING SYSTEM (AIMS)

The auditory system called AIMS has been designed for amphibians and birds, although the system could also be useful for monitoring any other wildlife groups that vocalize. The system as shown in Figure 1 consists of three modules:

1) a data collection module, which will hold over 12 hours of data on 4 channels among other features,
2) a data analysis and pre-processing module, which will

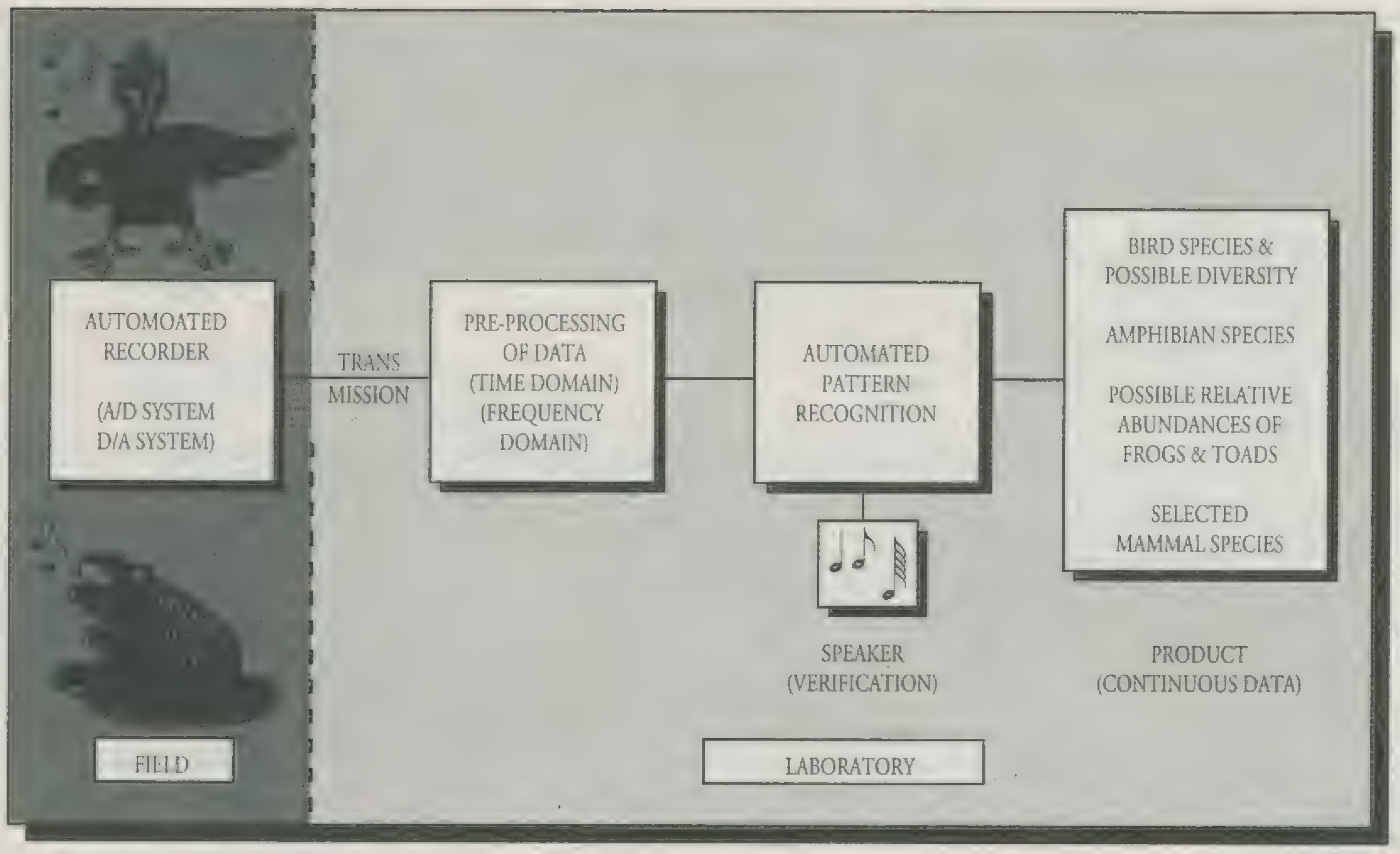

AUTOMOATED RECORDER
(A/D SYSTEM D/A SYSTEM)
TRANS MISSION
PRE-PROCESSING OF DATA (TIME DOMAIN) (FREQUENCY DOMAIN)
AUTOMATED PATTERN RECOGNITION
BIRD SPECIES & POSSIBLE DIVERSITY
AMPHIBIAN SPECIES
POSSIBLE RELATIVE ABUNDANCES OF FROGS & TOADS
SELECTED MAMMAL SPECIES
SPEAKER (VERIFICATION)
PRODUCT (CONTINUOUS DATA)
FIELD
LABORATORY

Figure 1
AIMS works through a series of four steps.

allow the recorded data to be processed for specific features, and

3) a pattern recognition component, which will help to classify and identify the wildlife calls. Eventually all three components will be integrated with the recorder unit.

Data Collection System (Recorder)

Currently under development, the prototype recorder is an intelligent, multi-channel, audio-band recorder. It is a portable IBM compatible computer with a 20 MHz central processing unit and an A/D (audio-digital) board of 16 bit resolution. This prototype recorder is being designed to record bird and frog calls from four different channels. Each channel has a wide dynamic range, which means even high- and low-pitched sounds can be sensed. The acoustic data are stored digitally on the computer. The system runs on either 120 volt AC or 12 volt DC with optional solar panels. An environmental enclosure has been designed and constructed to "house" the recorder unit and allows it to operate continuously under various environmental conditions (rain, etc).

The recorder collects data at multiple channels remotely using radio frequency (RF), thus permitting the use of this recorder in remote areas where tethered microphones are limited. One of the advantages of a multi-channel recorder is that one can obtain estimates of relative abundance using triangulation techniques. The area surveyed would be calculated using geometry and then the number of individuals per unit area would be determined.

Two types of recording systems are being developed, one time-triggered and the other voice-activated. The latter is activated only when triggered by an acoustic transient, such as a bird or frog call. If a transient or animal call is recorded on one of the channels, it triggers the recordings on all four channels, and thus, the entire sound is captured. Between calls, the computer streams the data from memory to disk. The event's start time is also recorded. The nominal duration of typical bird or frog calls is expected to be five seconds or less.

Under nominal conditions, the prototype instrument has been designed to hold over 12 hours of real time duration data for all four channels. In comparison, most commercial recorders currently available usually record data less than 2 hours in duration. This means the recorder can be set up and left to run all night–a great advantage given the reduced number of scientists, the inconvenient hours, and the many different locations that need monitoring. Typical monitoring locations for the recorder are shown in Figure 2, on the next page, which includes a Hydro transmission corridor and wetland sites.

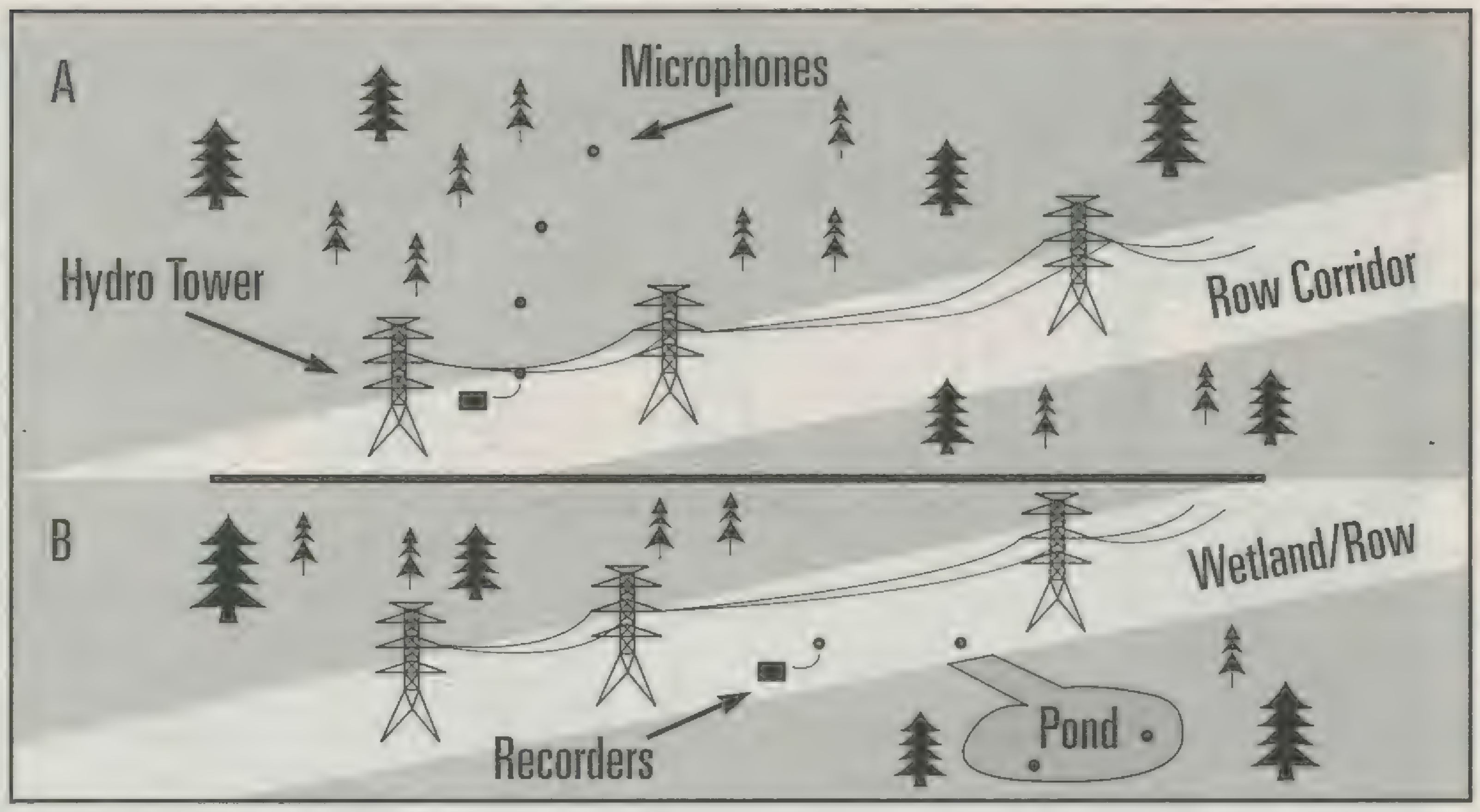


Figure 2
Here, typical monitoring locations for the recording system are shown.

Data Analysis and Pre-processing Software

An unique data analysis and pre-processing software package has been developed that allows recorded data to be processed for specific feature analysis, such as time history and frequency displays. It can also digitize signals collected by using analog cassette recorders (tapes from individuals, universities, government agencies or industry). This also allows the analysis of collected information using more traditional recording media. The less expensive tape recorder can therefore record information and yet still be analysed by this system.

Some features of the software package are as follows:

- transforms field data (audio signals) into digital format.
- data can be presented as both time history or in frequency domain (spectrogram, audiogram). An example of this type of data presentation is shown in Figure 3.
- ability to extract pertinent statistical information about the signal such as power, mean amplitude, etc.
- ability to reduce data sets to a more manageable size without much information loss (such as dominant frequency, average strength).
- provides a verification so that any digitized audio signal (whole or part) can be expressed as an audio output and/or viewed on a computer monitor.

The data analysis and pre-processing software has been specifically designed to handle large amounts of data. Further details of this package are given in Patrick and Tjew (1992).

In addition, a software program is being developed that can estimate the relative abundance of amphibians based on characteristics of their vocalizations. Estimates of relative abundance and species identification are both required for ecological diversity measurements.

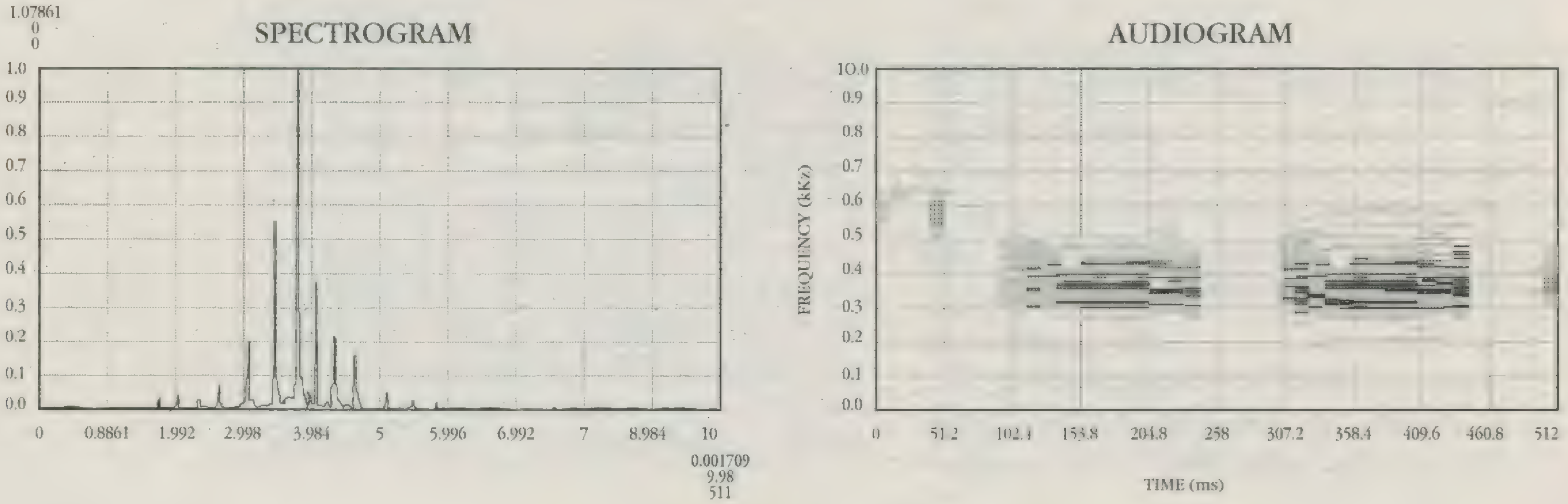


Figure 3
The spectogram and audiogram show the frequency domain plots of a chickadee.

Pattern Recognition Systems, such as Neural Networks

Once the sounds are collected, they must be identified. Neural networks, a system applied to the recognition of calls, are being used to classify the audio signal collected with the recorder.

Analog vocalizations of over 60 species of birds and amphibians obtained from Cornell University's Laboratory of Ornithology, McGill University, Ohio State University, and other sources (*e.g. Bird Sounds of Canada*) have been digitized for use as a "training set" for the neural network based pattern recognition system. These birds and amphibians represent species commonly found in the vicinity of Ontario Hydro's transmission corridors.

Figure 4 shows the proposed framework for the recognition phase. Each recognition module will include one or more 'experts' based on neural networks and/or rule-based systems. Work to date has concentrated on the identification of amphibian species.

The calls have been digitized at a sampling rate of 20 kHz and further pre-processed. A method based on the signal power and zero crossings was developed to determine the onset of the call. The prescreening block is used only in the recognition phase (not in the training phase) and is based on a simple unsupervised clustering technique. The primary purpose of this block is to filter out extraneous sounds. All the networks in this study were multi-layer perceptrons trained using the back-propagation algorithm (Rumelhart et al 1986).

Case	Model 1	Model 2	Parallel Combinations
A	100.00	100.00	100.00
B	96.6	98.3	98.3
C	96.6	98.3	100.00

Table 1
Percent Identified Correctly in the Test Set

Earlier studies on other pattern recognition problems (e.g., Ramani and Patrick, 1992) had shown that generalization can usually be improved by a parallel combination of two networks trained using two different encodings (preprocessing) of the data. Each preprocessor accentuates different features of the signal resulting in successes in different subsets of the input space and a parallel combination can combine the successes of the two.

Some test results on the amphibian species are summarized in Table 1 (the three cases correspond to three distinct training/test set combinations). The results to date are very encouraging with an overall identification success rate of over 98 % on clean signals. Clean signals comprise at least 70% of the data set.

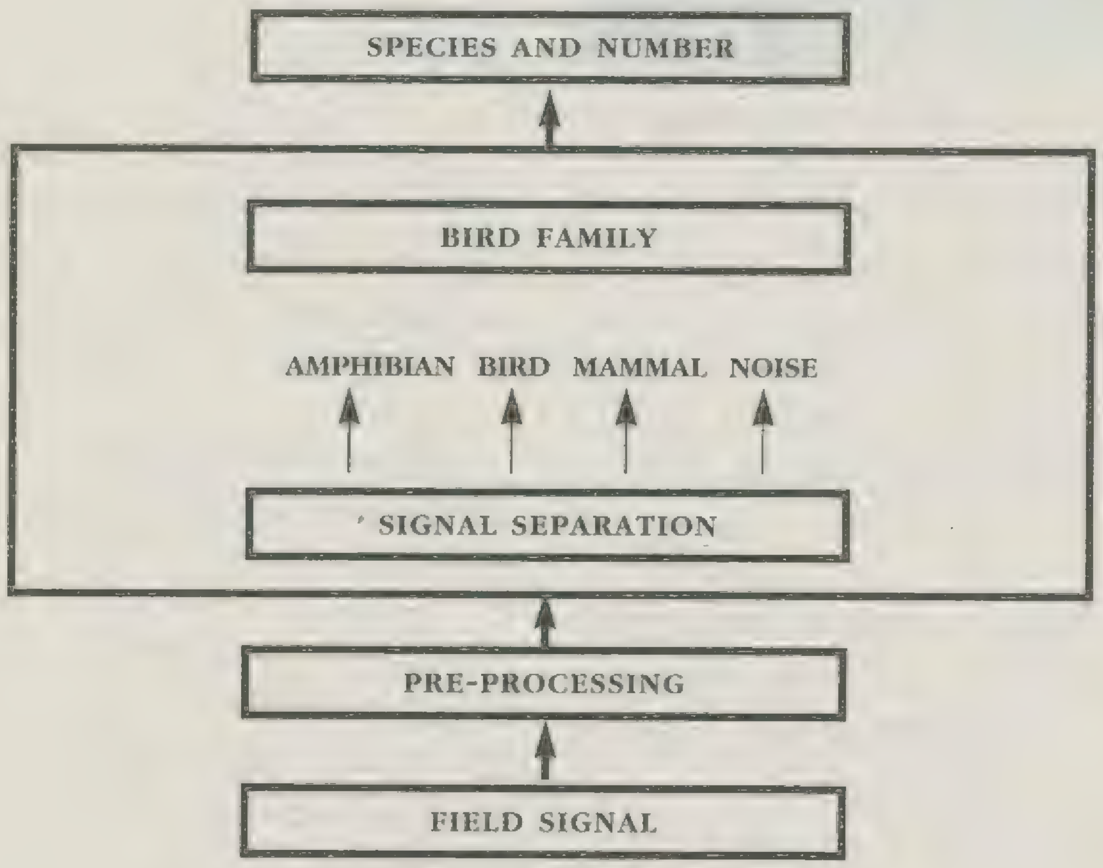
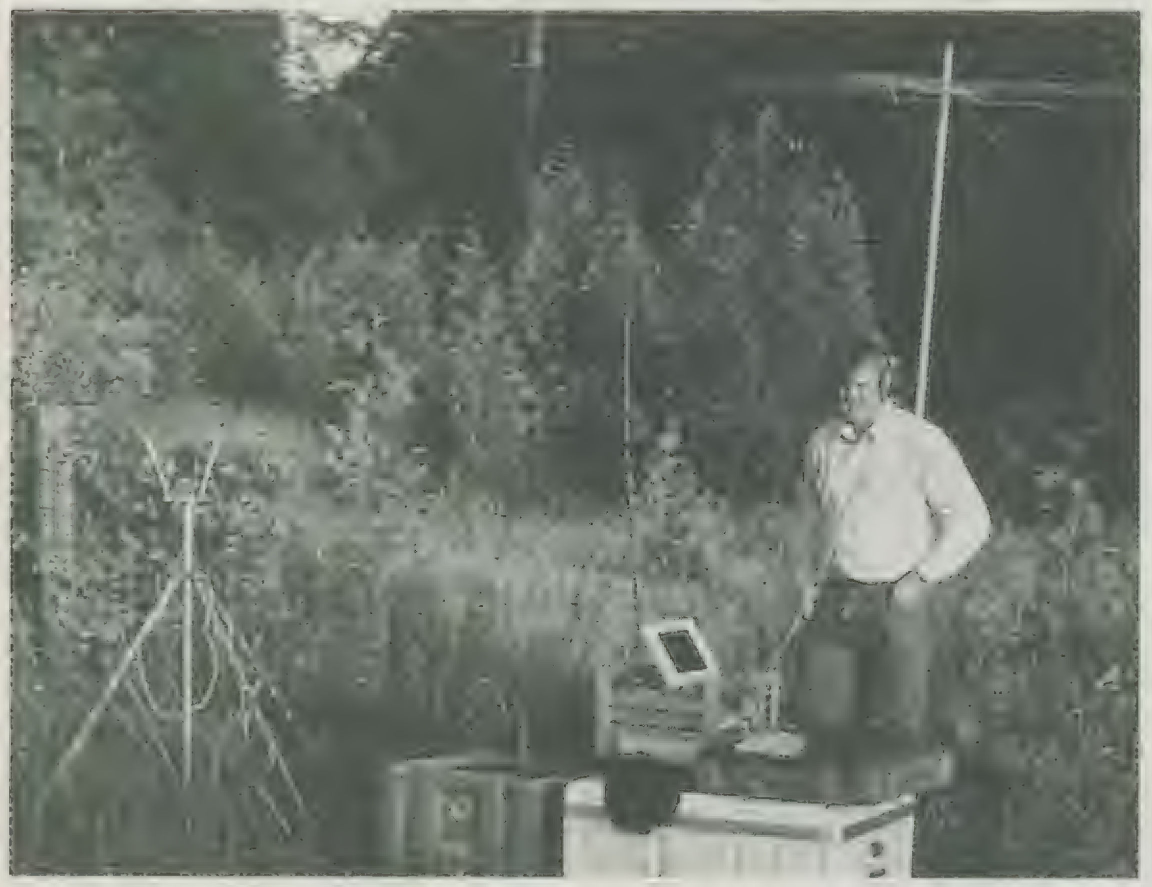


Figure 4
This schematic diagram shows the segmentation and coding pattern that is used to recognize individual species and their numbers.

FIELD EVALUATION OF AIMS

A preliminary field evaluation of the automated recorder has been conducted at selected ponds in the vicinity of the Toronto Metro Zoo. The emphasis at this site was amphibian monitoring (toads and frogs). The recorder successfully recorded both amphibian and bird species over several 24 hour periods (not continuously) using a multiple microphone array spaced up to 0.5 km apart. The system worked extremely well in collecting vocalizations. The presence of a species of frog not expected at the particular pond was even detected. The time and date at which the vocalizations occurred were successfully recorded. Estimates of relative abundances were also made.

Field evaluation is currently being conducted with the University of Waterloo on bird monitoring at a gravel pit site near Cambridge, Ontario.



Photograph of automated intelligent monitoring system in the field consisting of a portable computer with audio-digital board, up to four channels for microphones, storage of sounds on a 510 megabyte disk, and operation from 120 volt AC or 12 volt DC

Photo by Ontario Hydro

ACKNOWLEDGEMENTS

First we would like to thank Nick Kritopos (University of Western Ontario PEY student) for his significant technical contributions. We would also like to thank Bob Johnson, Curator of Reptiles and Amphibians at the Metro Zoo, and Lorraine Giza for their help in field work at the zoo site. Dr. Paul Eagles and Sarah Rupert of the University of Waterloo are also thanked for their cooperation at the Cambridge site.

CONCLUSIONS

An automated intelligent monitoring system is being developed as a cost effective means of collecting wildlife environmental data. This system has application in environmental assessments, contaminant studies, resource management, and biodiversity investigations.

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Cholera, Plankton Blooms, and Ballast Water

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The transport of exotic organisms in ships' ballast water has many environmental and human consequences. Knowledge of biodiversity is essential to understanding the consequences. Continuing growth in poverty and population levels can multiply these impacts.

Editor-in-Chief

At a cursory glance there doesn't appear to be any relationship between cholera, plankton blooms, and ballast water. Let's look at the three individually:

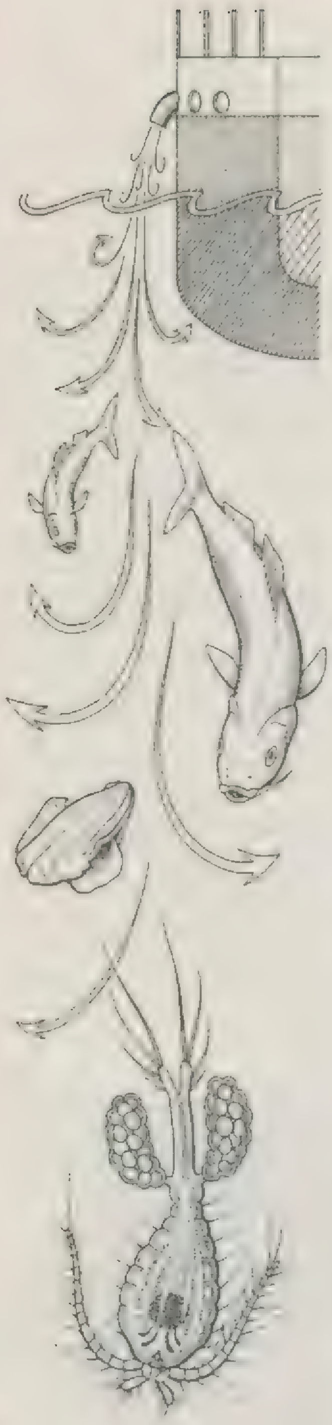
- Cholera is a severe infection of the gastrointestinal tract in humans characterized by profuse diarrhea, dehydration, and rapid death within 48 hours, if left untreated. Death is due to a massive loss of electrolytes from the body with a resultant collapse of the homeostatic mechanisms or those mechanisms that maintain a constant internal environment in animals, such as constant osmotic pressure, acidity level, temperature, and concentration of blood gases.
- Plankton blooms occur at certain times of the year when the phytoplankton (plant plankton) and zooplankton (animal plankton) have a burst of growth after a fairly long quiescent period.
- Ballast water is the water that ships take on prior to oceanic voyages to give them balance while underway at sea.

The three are apparently disparate entities. But with a little detective work, the three can be put together to explain the onset of cholera epidemics and their potential spread to parts of the world where normally cholera is not seen. There have been several recent outbreaks of the disease in areas of South America and southern Mexico. The outbreaks have happened along the ocean shores and are generally associated with villages whose main occupation involves fishing. Could such epidemics spread to the interior of the countries involved? Could they lead to outbreaks on Caribbean Islands, the interior of Mexico, and the continental United States? These concerns are based on the concept that humans are carriers of the disease. This may be a real threat, but cholera may reach such areas by a far different method than inside a human gut.

For a long time cholera was considered to be a primary disease of man, and the causative organism *Vibrio cholerae* was thought to reside in the gut of asymptomatic carriers. This concept is still held by some public health authorities. But recent work has established that the bacterium is an autochthonus water dweller, or an original inhabitant of water, and is found in both fresh and brackish waters. The organism produces an enzyme, chitinase, which breaks down chitin--the substance found in the exoskeletons of numerous zooplankton. Chitin, in fact, represents a large amount of waste material found in water habitats. By breaking down chitin, the vibrio play an important part in aquatic nutrient recycling.

The relationship between plankton and *Vibrio cholerae* was first pointed out by Rita Colwell and her colleagues in 1977 and has since been expanded by her group and others. The organism has been found under such conditions in Bangladesh, Louisiana and Chesapeake Bay in The United States, and in the estuarine waters of Kent in England.

Vibrio cholerae attaches to the surface and eggs of copepods, or chitinous zooplankton. They prefer to attach to the moulted exoskeletons rather than to whole specimens, probably because the intact copepods are covered with waxes to which the organism cannot attach.



In addition the growth of vibrio appears to be stimulated by the presence of zooplankton, although the exact mechanism is not known. It is of interest that water hyacinths also have this property. Vibrio abound in the gut of many fishes, particularly those that feed upon zooplankton. These fish, in turn, undoubtedly play a major role in the primary transmission of cholera to man, for it is only when the vibiro enter the body in infectious numbers that disease occurs. Such occurrences result when the fish are caught, cleaned, and consumed under conditions associated with poor hygienic standards–poor sanitation while handling food, ingestion of contaminated food or water, and overcrowding.

In Bangladesh, during the monsoon season (May to July), the rainfall is so heavy that the nutrient rich waters are greatly diluted. During this period the plankton, and the vibrio, remain quiescent, in an almost dormant state. With the rapid increase in nutrient levels after the monsoons are over (August and September), there is a burst of planktonic bloom and concurrently, vibrio. Not surprisingly, this period of time corresponds to the period of cholera epidemics. During this time fish also become infected with the organism and become sources of infection when used as food. The latter appears to be the main method of transfer in South America, but undoubtedly, plankton are involved as well. Climatic conditions are also responsible for quiescent and growth periods of plankton in temperate climates and vibrio growth follows the same patterns.

Now for the last piece of the puzzle, one which hasn't had much serious searching for but appears to be logical: What happens if ballast water is taken on during a plankton and vibrio bloom? Ballast water is rapidly becoming a worry in ecological circles because it overcomes the geographic barriers to the dispersal of organisms, permitting successful exotic species to displace native species. We are all familiar with the larger organisms that arrive as immature forms in ballast water or as adults attached to the hulls of ships, primarily mollusks. The best publicized Canadian example is the arrival of the Zebra Mussel in the Great Lakes. But countless thousands of other microscopic organisms arrive each day in the ballast water of ships from foreign ports. Carlton and Geller in a report aptly called "Ecological Roulette," point out that "the transport of entire coastal plankton assemblages across oceanic barriers to similar habitats renders bays, estuaries, and inland waters among the most threatened ecosystems in the world." In their study, plankton samples were taken from the ballast water of Japanese ships, which was then released into the waters off Oregon. The water contained 367 taxa of organisms; most of these had a planktonic phase in their life cycle!

In order to address this problem an international survey was established to enquire into the effectiveness of guidelines designed to control the discharge of ships' ballast water. The group was set up by the International Maritime Organization's Marine Environment Protection Committee (MEPC). Under the chairmanship of Australia (other members are the U.S.A., Canada, U.K., Japan, and New Zealand), guidelines have been established to control ballast water discharge. How effective these guidelines will be remains to be seen.

From this brief discussion, the ecological webs that exist in all sorts of situations can be seen once again. The disturbances of such webs have profound effects, not only on the environment but also for the humans who become enmeshed in them. The latter situation will be explored in future articles.

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American Beaver
Castor canadensis

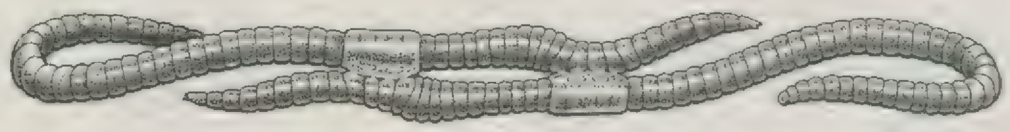
American Beaver

Castor canadensis

The American Beaver, *Castor canadensis*, ranges from Alaska through Canada and the United States to northernmost Mexico. A related form is found in Europe.

A new Canadian Museum of Nature exhibit that is under development will focus on the beaver and explode many of the myths surrounding this national symbol. *Fact or fiction?* The beaver slaps its broad tail on the water to alert others to danger. Fiction: Although it may sometimes alert other beavers, the purpose of this sudden action and noise is to startle intruders for a few vital seconds so the beaver can escape underwater. *Fact or fiction?* The beaver uses its tail as a trowel to plaster mud on the dam or lodge. Fiction: A beaver plasters mud with its hands, not its tail. However, its tail is very important and serves as a rudder, prop, and lever.

Aside from humans, beavers are one of the few animals to dramatically change the habitat in which they live. Termites, gypsy moths, etc. also change their habitats. Beavers construct dams across streams, ponding up water behind to a depth of two to three metres. The dams of the 10 to 12 million beavers in North America moderate the flow of water in streams and rivers. Their ponds fill with water at times of peak flow, and then due to the dam, the water is gradually released. Additional water is stored by elevating the water table behind the dam. Cumulatively beaver dams help moderate the flow of water throughout North American rivers.



Harmonizing water cycles:

A two-billion-dollar flood prevention plan

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U.S. Congress recently authorized $5.7 billion to pay for part of the estimated $12 billion damage done by flooding of the Mississippi-Missouri river system in 1993. In this point-of-view article a $2 billion plan to ***prevent*** *floods, working with nature, is proposed. An added benefit is that this plan can recharge declining ground-water supplies.*

Editor-in-Chief

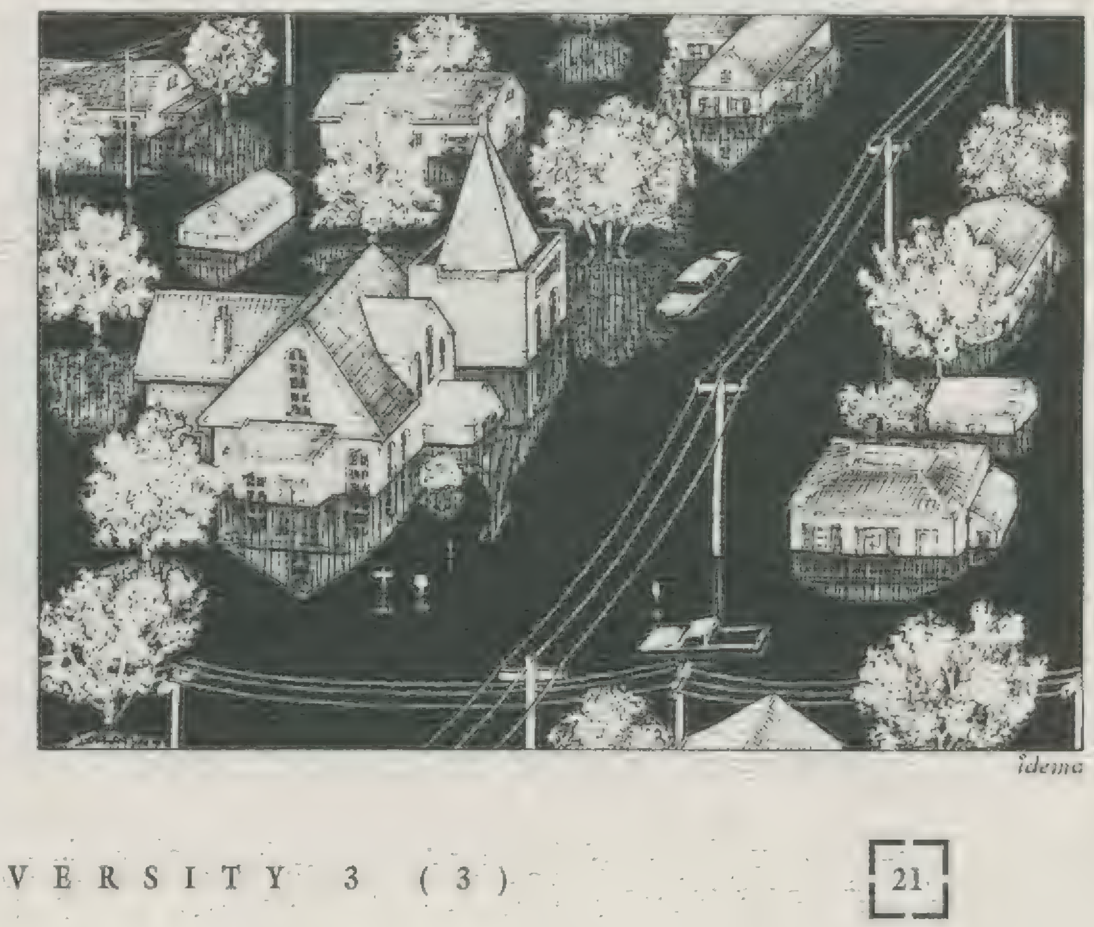
> A useful contact with the Earth places man not as a superior to nature but as a superior intelligence working in nature as a conscious and therefore as a responsible part of evolution, which is a continuing creation.
>
> Liberty Hyde Bailey, *The Holy Earth*

INTRODUCTION

Recent floods, such as "the Great Flood of '93" in the American Mississippi-Missouri River system and in the Canadian Red River system have caused billions of dollars of damage. Flood water covered 41.4 thousand square km of land in the United States. While a great deal of media attention has been devoted to the devastating effects of these floods, little attention has been focused on the underlying causes of such flooding. The usual engineering response to floods is to build more control structures – dams, levees, dykes, flood diversion canals, etc. In this viewpoint, natural preventative alternatives are suggested as replacements, or at least as complements, to current engineering structures.

Flooding is a natural phenomena that occurs when river systems or other low lying areas can no longer accommodate rapid runoff generated by heavy rains or the melting of snow or glacier ice. But present day human activities are increasing the frequency and height of natural flooding. As society tampers with the environment and its natural ecosystems and alters the natural landscape, Nature's flood moderation mechanisms are reduced or impaired. The recent devastating floods in the United States and Canada should warn us of the growing consequences we will face if development continues to be based on immediate economic benefits rather than on an understanding of the environment and its eco-services.

As mentioned before, the traditional response to flooding has been to commission engineers to design and build more control structures to control runoff, *once it has*



idema

reached rivers. Such engineering solutions are costly, and often prove ineffective, as we have just seen so dramatically:

*Nearly 70% of the about 7,500 km of levees in the Mississippi-Missouri basin were overwhelmed (*Globe and Mail,* 24 August 1993, p. A1 & A5).

*The Army Corps of Engineers has proposed a 33 km-long tunnel to reduce flooding in New Jersey's Passaic River basin, which has been subject to repeated floods. The cost of the giant tunnel, which would empty into Newark Bay, is estimated at $2 billion.

*Although almost the entire main channel of the Los Angeles River in California and more than 640 km of tributaries are encased in concrete levees, the Los Angeles Department of Public Works and the U.S. Army Corps of Engineers who manage the river system have come to realize that even it will not withstand a 100-year flood, the standard for which it was designed (Williams 1993). Even an almost completely channelized and encased river will still flood!

*The World Bank is preparing to lend US$620 million for the Xiaolangdi Dam on the Yellow River in China, near the ancient imperial city of Luoyang. The dam is intended to provide for flood control, reduce siltation in the lower reaches of the river, provide irrigation, and generate hydro power, but critics say its design is so seriously flawed that the dam itself may cause floods once its reservoir is full of silt and gravel. The US$10 billion Three Gorges Dam on the Yangtze, if completed, would dwarf the Xiaolangdi Dam (*Probe Alert*, September 1993, p.1).

Obviously there are shortcomings to a purely engineering solution. These solutions usually ignore the inappropriate placement of buildings and human activities. Flood damage occurs when communities, farms, and other human activities are placed on flood plains or are built on filled-in wetlands. This has two sets of costs: 1) loss of human lives in addition to damage to buildings and activities, and 2) damage to the concomitant engineering "solutions." There is a third cost, not often recognized. Sediment is no longer deposited on the flood plains, but dropped in the river channel, forcing additions to the height of levees.

New U.S. federal flood insurance rules go part of the way in requiring that houses that sustained damage of 50% of their value should not be rebuilt unless set above the 100-year flood level. The Federal Emergency Management Agency has suggested erecting buildings on stilts in flood-prone areas.

> ▪ *Natural flood prevention focuses on slowing or storing the water* ***before*** *it reaches the rivers.*

In contrast to the engineering solutions often used, natural flood prevention focuses mostly on slowing or storing the water before it reaches rivers. The following discussion compares different forestry and agricultural practices on land that slopes gradually or steeply toward a water course. But the hydrological cycle involves more than the movement of water on and through the ground. Natural vegetation transpires water back into the atmosphere where it can form clouds and fall again as rain. Ecologically-oriented agriculture and forest management can profoundly modify both ground and atmospheric water cycles.

FORESTS

In this section, the effects of two forest management approaches on flooding are contrasted: eco-forestry and clear-cut industrial forestry. (For more details on these forest management practices see Hammond 1991; McAllister 1993).

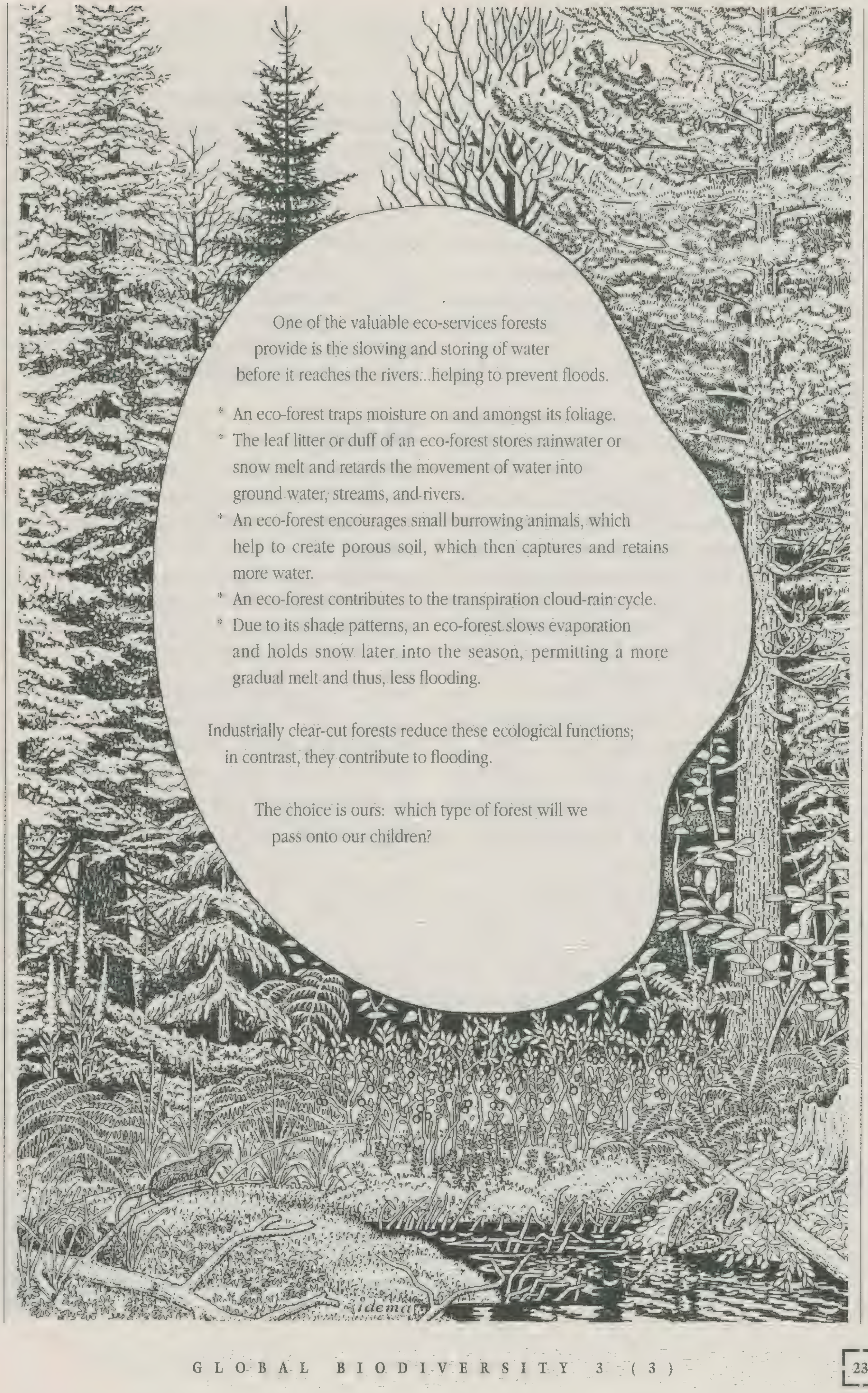
Foliage/Tree cover

The foliage of a naturally managed forest or of an older even-age forest catches and holds some of the falling raindrops, gradually letting the drops fall to the ground and, in the process, letting some of the moisture evaporate into the air. The more foliage a tree has (often proportional to their size), the more moisture that can be temporarily retained by the foliage. Clear-cut areas or even clear-cut areas recently planted with seedlings hold little or no moisture on their foliage, and thus, more rainwater flows into a river from these areas.

In eco-forestry the importance of tree cover is especially emphasized on sloping land and on river banks. The trees, roots, and leaf litter reduce the downslope and riverward movement of water.

Leaf litter/duff

Duff, which consists of whole or partially decayed leaves, twigs, and branches, forms a layer on top of the forest soil. Duff is thicker in older forests and those managed by eco-forestry. It takes a while for the rain to seep



One of the valuable eco-services forests provide is the slowing and storing of water before it reaches the rivers...helping to prevent floods.

- An eco-forest traps moisture on and amongst its foliage.
- The leaf litter or duff of an eco-forest stores rainwater or snow melt and retards the movement of water into ground water, streams, and rivers.
- An eco-forest encourages small burrowing animals, which help to create porous soil, which then captures and retains more water.
- An eco-forest contributes to the transpiration cloud-rain cycle.
- Due to its shade patterns, an eco-forest slows evaporation and holds snow later into the season, permitting a more gradual melt and thus, less flooding.

Industrially clear-cut forests reduce these ecological functions; in contrast, they contribute to flooding.

The choice is ours: which type of forest will we pass onto our children?

Art courtesy of Ocean Voice International through the duff to the soil, and some rain is soaked up by the duff itself.

In many industrially managed forests duff is burned off with logging slash before replanting. Therefore, in clear-cut and recently slash-burned and replanted sites, most of the rain strikes the soil immediately. As the raindrops collect and fuse on the soil, some soak into the ground but most runs off, carrying away irreplaceable soil.

▪ *Leaf litter and soil humus in forests help store and retard movement of runoff from rain and snow melt, reducing the potential for flooding.*

Soil

Rainwater tends to drain into sandy soils, whatever the style of forest management. But other types of soil may differ under eco-forestry and industrial forestry management, to greater or lesser degrees. Soil will be more porous where there are an abundance of soil burrowing animals, such as arthropods, worms, and rodents. The spaces they create between the soil particles hold water. Water or air-filled spaces occupy about half the volume of healthy soil. More burrowing animals are to be expected in natural forests, than those that have been exposed to slash-burning.

Is the transpiration cycle being interrupted by deforestation? Probably, and thus these deforested areas are contributing to periods of both flood and drought.

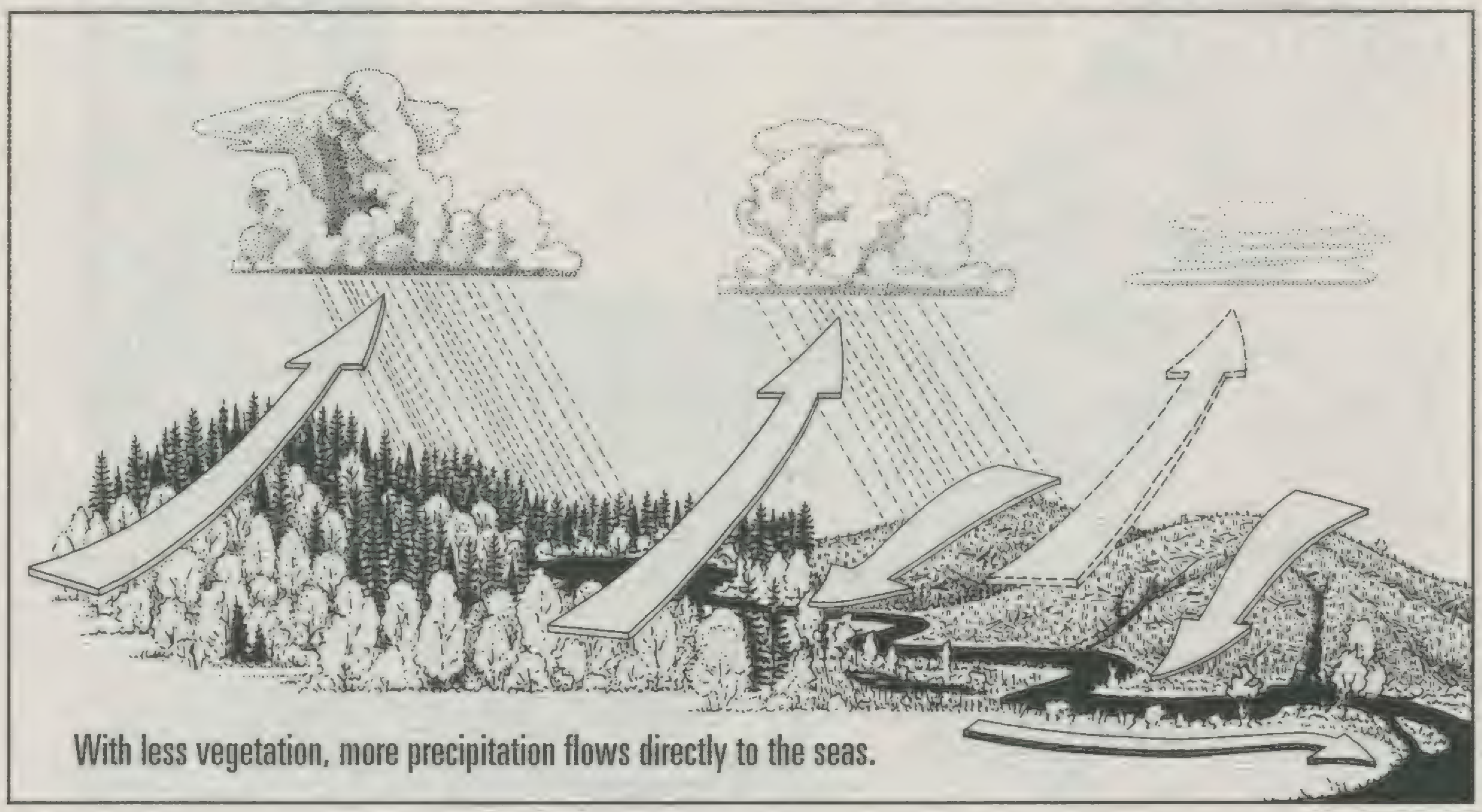
Also in eco-forestry, the leaves, twigs, branches, and fallen trunks gradually move into the soil as they decay. Some trunks may take a century or more before completely rotting away. This organic material, and the humus into which they transform, is capable of holding considerable quantities of rainwater or melt water from snow or ice. Twigs and branches also form natural conduits along which moisture runs. Where not lost through surface evaporation or absorption by plant roots, this water moves into the water table and is gradually released into streams and springs.

Conversely, the heavy equipment sometimes used for industrial logging may compact the soil, reducing its porosity. Thus, rain on recently clear-cut and replanted areas is more likely to run along the surface into the nearest watercourse; less will enter the soil or be held there in spaces between soil particles, or in the almost non-existent decaying organic matter or humus.

Transpiration

Transpiration is the exhalation or breathing out of water vapour from leaves, the water having been brought up the stem of the plant or trunk of the tree in the xylem. Transpiration takes place to an equal degree in eco-forests and older even-aged growth of industrially managed forests. Huge volumes of water are drawn out of the ground and evaporated into the air by forests; to collect in clouds and later fall again as rain.

In contrast, transpiration is lacking or reduced in clear-cut areas or newly replanted clear-cut areas. In the deforested areas of the Amazon it is suggested that the rain-cloud-rain cycle of transpiration is being interrupted, and water is flowing more swiftly and directly to the sea.



With less vegetation, more precipitation flows directly to the seas.

In India, as the forests give way to farmland, it has been hypothesized that the monsoon succession of rains is similarly affected (Frater 1990). Newly clear-cut and replanted areas would similarly shortcut this hydrological cycle, and thus contribute to periods of flood and drought.

Humidity bank

The space between the trees is commonly more humid than above the trees or outside the treed area, due to transpiration and evaporation of moisture from duff and soil. So the forest air acts as a temporary "bank" for moisture. This "bank" is lost in clear-cut areas, and again the moisture travels to the nearest watercourse.

Shade

The foliage of a maturing or mature forest, whether an eco-forest or an even-aged plantation plot, absorbs solar energy in its leaves and shadows the ground. Snow consequently lasts longer under the trees, especially under evergreen trees, than it does in the open, or in clear-cut or newly replanted areas. Eco-forests thus contribute to holding large quantities of moisture as snow, later into the season, than in treeless or newly replanted clear-cut areas. This results in a more gradual melting of the snow, and thus, in less flooding.

The contribution of trees to moderating runoff can be enhanced through encouragement of eco-forestry, and replanting deforested and treeless areas in the country and in communities. The American Forestry Association estimates that there are 100 million sites where additional trees could be planted around our homes and communities (Robert Rodale, 1989. *Tree's new role.* Organic Gardening 36(4): 27).

▪ *Ecologically oriented agriculture and forest management can profoundly modify both ground and atmospheric water cycles.*

FARMLANDS

Organic farming or permaculture seeks to introduce principles learned from nature into agricultural practices (Coleman 1989; Mollison 1990). Some of these natural practices may contribute to moderation of runoff and so reduce flooding. This is in contrast to industrial farming, characterized by monoculture, more exposure of bare soil to the elements, and the use of heavy machinery and agrochemicals. As several of the processes in agriculture are similar to those occurring in forests, the discussion has been abbreviated.

Vegetation cover

Natural farming seeks to maintain vegetated soil cover, thus reducing the seasonal exposure of bare soil found in industrial agriculture. Crop leaves have similar effects to the foliage of trees on rainfall, and the vegetation on stream banks is just as important in agriculture as in forestry. Organic farmers retain stream bank vegetation and, using fencing, provide limited access of livestock to streams.

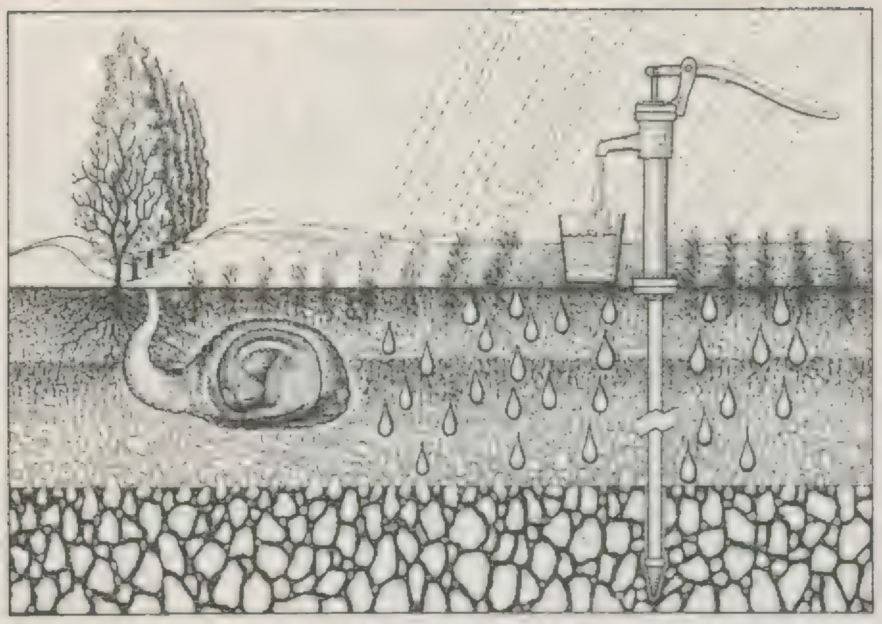
Stubble left on fields and trees planted in shelter breaks retain snow across the farmland, instead of letting it drift into gullies where it will quickly run off in spring. If perennial varieties of corn were developed, then the benefits of vegetation cover would be correspondingly increased. The potential exists for developing a perennial variety from the recently rediscovered wild Mexican corn species, *Zea diploperennis* (McAllister and Whiting 1992; Small and Cayouette 1992).

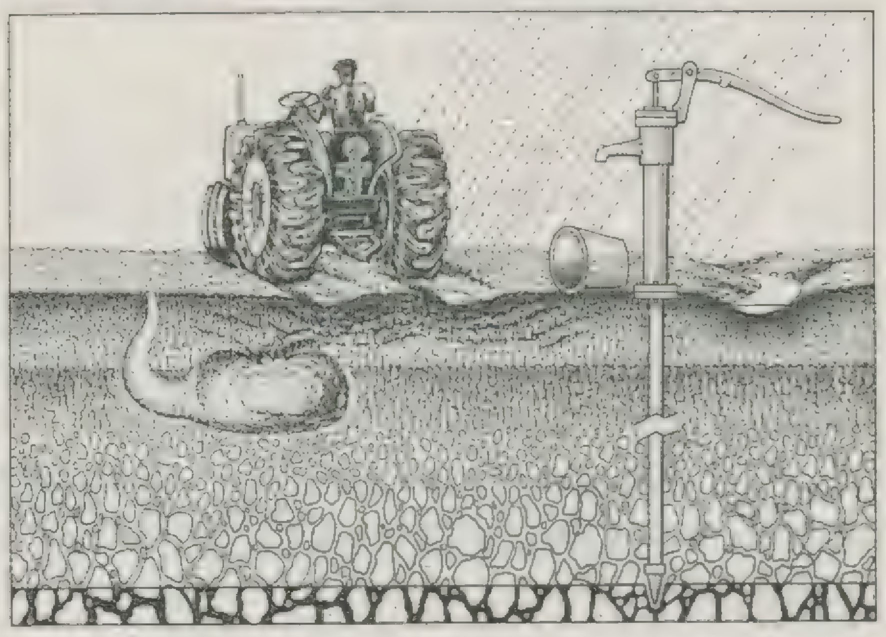
Mulches can also help the soil moisture. Alfalfa mulch will not only help retain soil moisture, but also keep down weeds, supply nutrients, and add organic matter to the soil. The NITRO variety is especially effective in adding nitrogen to the soil.

Soil

Natural farming encourages worms and other soil species because they help recycle nutrients and improve soil porosity. Reduced tillage practices maintain porosity that helps rain and snow melt penetrate the ground, instead of running off the land into rivers. The agrochemicals and heavy tillage used in industrial agriculture eliminate many soil organisms and the soil porosity they create. Heavy farm machinery compacts the soil, also reducing its porosity. About half the volume of healthy soil consists of spaces created by soil organisms. Taking into account the upper half metre of soil, a farm with healthy soil could hold in the order of 5,000 cubic metres of water per hectare in its pores. Healthy soil can thus act as a huge sponge to soak up water. Lands farmed with organic methods, therefore, divert more rain and snow melt into the soil, instead of encouraging rapid runoff.

▪ *About half the volume of healthy soil consists of spaces created by soil organisms. Healthy soil can thus act as a huge sponge to soak up water.*





How would you farm this land? Would you farm it with natural farming methods, which encourage retention of soil, soil porosity, and the recharging of the water table? OR would you farm it with modern methods, which encourage erosion, soil compaction, and the overuse of the water table?

Humus

Natural farming endeavors to enhance humus levels in those soils where it has been reduced or is naturally low. It does this by returning plant stalks, manure, and other agricultural "wastes" to the soil, or by mulching. Mulching provides the agricultural equivalent of forest duff. Higher humus levels increase the water holding capacity of the soil, which in turn, moderates runoff and downstream flooding.

Industrial farming can significantly reduce the amount of humus in the soil. In the northern prairies, for example, the level of organic matter has declined between 36 to 49% in the last 30 years (Environment Canada 1991). If humus absorbs twice its dry weight in water, then that humus loss over thousands of square kilometres could have an enormous effect on runoff and downstream flooding.

Suppose that the weight of dry humus under a metre of soil surface falls from 100 to 50 grams and suppose that humus can absorb twice its weight in water. That means that each square metre of soil has lost the capacity to hold 100 grams of water, and therefore each hectare has lost the capacity to store 10 cubic metres of water. Now scale this up to the 25 million hectares planted with corn in the U.S.A. or the 31 million hectares under wheat in Canada! These huge values surely influence the degree of downstream flooding. In our opinion, the relationship between floods and modified and/or natural ecosystems definitely needs more study.

In large part, existing government soil conservation programmes have not worked. Imaginative new approaches are needed whereby farmers, forest managers, and others directly benefit when wise conservation programmes are successfully applied. For example, taxes might be reduced on those farmers who managed to build up the humus content of their soil and to arrest erosion.

Transpiration

The more vegetation cover is retained throughout the year, the more rainfall will be transpired, rather than run off into rivers. Natural farming does this using a variety of means including intercropping, alley farming, etc.

Farming and ground water

Underground water supplies half of the drinking water in the United States and 97% in rural areas (*Organic Gardening* 36(4): 10) and is important for crop irrigation and watering stock. Yet water tables are dropping as more water is pumped for growing populations and agricultural irrigation. Increasing contamination of the ground water used by humans provides the clue that much of it is supplied from precipitation on farmland. According to the Environmental Protection Agency, pesticides have been linked to contaminated ground water in 38 states. If improved farming practices lead to less runoff (with hopefully lowered pesticide use) and more percolation of water into the soil and thus, greater storage of water in the soil, then this should lead to the recharging of underground water supplies–which are falling in many parts of the U.S.A. Thus appropriate farming practices can result in both more water in the ground for drinking and irrigation and less for river flood crests.

- *Natural flood control methods can lead to better recharging of ground-water supplies.*

BEAVER PONDS

Beavers construct dams across streams. These hold back in the order of 1,000 cubic metres in the stream and slightly elevate the water table. Individually these dams appear to hold back small amounts of water, but think about the effect en masse. There are about 2 million beavers in the U.S.A. and 6-10 million in Canada (*National Geographic*, Earth Almanac, January 1993). Collectively, these millions of beavers in North America may help dampen spring flooding, and because their dams elevate the water table, they ensure stream flow in times of drought.

WETLANDS

Wetlands include marshes, swamps, bogs, fens, sloughs, and other water rich ecosystems. Typically they interface between dry land and streams, rivers, or lakes. They perform a variety of important functions, such as receiving runoff from land. Their rich aquatic vegetation and organic debris impede the rapid movement of water. They store rainwater and snow melt by acting as a sponge-like reservoir in times of peak runoff and gradually release this stored water in times of low flow. Peat and other decaying organic materials soak up moisture, just as humus and duff do for soils.

These and other important functions of wetlands are being reduced through agricultural drainage programs, often underwritten by government, or through land filling for commercial uses. Some 54% of the natural 87 million hectares of wetlands in the 48 adjacent states in the U.S. have been lost since European settlement. About 79% of this wetland loss has been in the Mississippi-Missouri basin.

▪ *Peat moss can hold more than 3 times its dry weight in water. Peat moss and soil humus store water and can help prevent floods.*

A simple experiment, which could be carried out in a school lab or a kitchen, shows how much water peat moss can absorb. One litre of dried peat moss, weighing 105 grams, was stirred with a half litre of water. After five minutes, it was then drained for another 5 minutes through a sieve. Then the peat moss was re-weighed. It weighed 385 grams, demonstrating that peat moss can hold 3.7 times its dry weight in water. Think how much water a peat bog holds! All too often peat bogs are drained for agricultural purposes or the peat is extracted and burned as a biomass fuel.

FLOOD PLAINS

Flooding is a natural phenomenon, and the land surrounding a river or stream is called a flood plain. It is the area on which the overflowing of watercourses during certain seasons has taken place for centuries. Flood damage often occurs when humans have erected buildings or are carrying out flood-susceptible activities on these very same flood plains. Some states have passed laws forbidding the erection of new houses or other buildings on lands subject to flooding. This defends the state from expenditures necessitated when heavy flood damage occurs. Obviously, such laws are sensible and should be passed by those states or provinces lacking them. The question remains, to what extent should governments work towards encouraging removal of existing structures and activities from areas subject to frequent flooding?

The question remains to what degree the World Bank and the regional banks should continue promoting large-scale dams to control floods. The World Bank plans to spend $15 billion for embankments and levees along Bangladesh's 24,000 km of rivers and streams (Serrill 1993). China is moving ahead with the controversial Three Gorges Dam project, in part for flood control. Reforestation and other natural food prevention techniques should be investigated for these and other areas.

▪ *Is a flood too much water in the wrong place? OR is it too many human activities in the wrong place—on a natural flood plain?*

TWO-BILLION-DOLLAR ALTERNATIVE

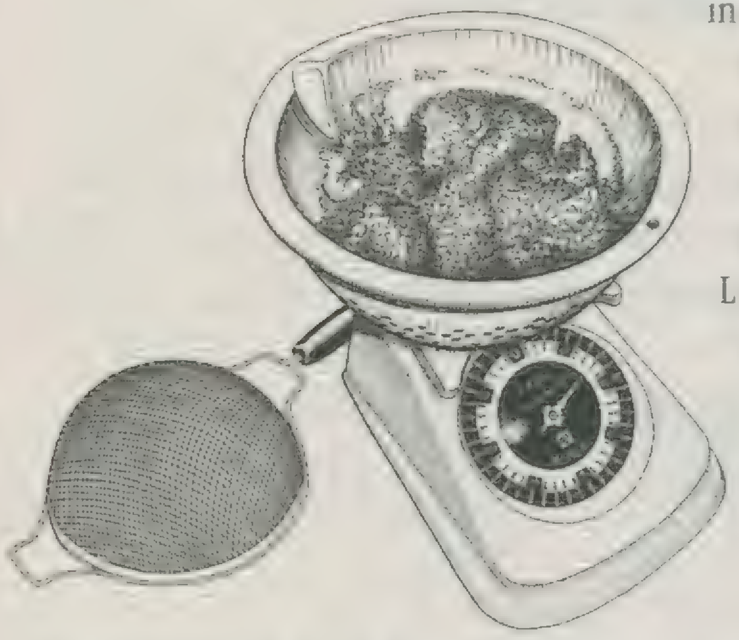
We now propose a $2-billion dollar program to help restore natural ecosystems through ecologically sustainable use of forests, farmlands, and wetlands. Partial use of natural control measures in the Mingo Creek flood plain near Tulsa, Oklahoma, has succeeded with flying colors. A full-measure pilot study on one basin in the Mississippi-Missouri system should demonstrate its practicality. Experimenting with potential projects, such as increasing humus levels in soils, may suggest which projects are the most beneficial for a given investment and time frame. Component project activities could include:

- Increase the use of eco-forestry with selective, ribbon, or small patch cuts instead of large clear-cuts, thus reducing runoff through continuous vegetation cover, more leaf litter/duff, and higher soil humus levels. $350 million.
- Replant deforested areas with a variety of native trees, grow more shelter belts and hedgerows on farms, thus

allowing for the "banking" of moisture. $550 million.

- Use natural farming methods that reduce bare soil exposure and tillage, increase vegetation cover, enhance the natural fauna of soils, its porosity, and humus levels, thus bringing back the spongelike quality of soil. $550 million.
- Restore wetlands, eliminate loss of further wetlands, undevelop flood plains, and encourage beavers, thus increasing the number of spongelike resevoirs throughout North America. $300 million.
- Reward those who restore and maintain ecological services contributing to natural flood control. $200 million.
- Provide engineers with courses in basic ecology with field work. $50 million.

These approaches will have other benefits, as well as some costs. Some farmland may have to be given up to restore wetlands. On the other hand, grain production may be higher on farms with restored soils in dry years due to the increased capacity of the soil to retain moisture. Erosion of forest and farm soils will decrease, enhancing future prospects. Lowered sediment loads and seasonally moderated river discharge rates will mean prolonged capacity for existing hydroelectric installations. The numbers of wildfowl may increase as wetlands are restored. The numerous benefits of eco-forestry are summarized in McAllister (1993).



A CLASSROOM EXPERIMENT

How much water can peat moss hold?

1. Finely crumble a litre of dry peat moss.
2. Weigh it in grams.
3. Put the peat moss in a bowl and cover it with water.
4. Stir the peat moss and water well with your hands.
5. Wait 5 minutes.
6. Place the moistened peat moss in a sieve in the sink.
7. Let the peat moss drain for 5 minutes.
8. Reweigh the peat moss.
9. Calculate how many times its dry weight in water peat moss can hold.
10. Learn from what plant(s) peat moss is made. Learn about bogs, swamps and other wetlands. Study soil. Find out what *humus* is.

SUMMARY

Ecological solutions to flooding deserve as much attention as engineering solutions. These include ecologically sustainable methods of forest management (eco-forestry, reforestation), natural farming methods, undevelopment of flood plains, and restoration of wetlands and river banks. Millions of cubic metres of water can be stored in healthy forest lands, farmlands, wetlands and beaver ponds, reducing rate and peaks of runoff. The bonuses abound and include the recharging of the water tables and the enhancement of wildfowl populations. Research, education, tax, and other measures could be introduced to encourage ecological methods of flood prevention.

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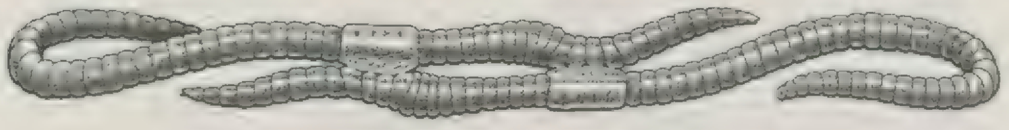

BIOTECH CORNER:

Slippery fish and boat efficiency

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In a recent paper scientists describe the drag reduction provided by mucus on the skin of fishes (Bernadsky, Sar and Rosenberg 1993). Drag reduction by mucus means that the fish have to perform less work in swimming through the water. The drag-reducing mucus was more pronounced in "with burst swimming" fish–those that quickly accelerate–and in larger fishes. The mucus layer on the skin may reduce the friction by up to 50% or sometimes more. These research results raise the question of whether practical applications can be made of these findings to human activities.

Boat engines work to accelerate the boat through the water, displace water, and to overcome friction and turbulence. The application of an artificial mucus to the boat's hull could reduce the amount of energy expended, and hence save fuel. Mucus could be fed out over the boat's surface from the ship's bow, or through openings placed at critical points along the hull.

The fish data suggest that boats that stop and start frequently, those that often accelerate, or large boats would benefit the most from mucus-based drag reduction. Candidates for the former would include the tug boat's that manipulate log booms. Candidates for the latter include oil tankers, which are amongst the largest ships that regularly make long trans-oceanic voyages.

A third category of ship for mucus drag reduction might include those where propulsion is very costly or where an extra measure of speed is difficult to attain, but critical. Candidates for this third category might include deepsea submersibles. Propulsion batteries for the latter occupy considerable space and are expensive. Most such submersibles are limited to underwater speeds of less than 10 knots. Those that depend in large part on sinking to reach the bottom, could have their descent times shortened.

Kayakers might appreciate a little extra efficiency on long distance trips, or when they have to paddle towards land when the wind is on the rise. What would artificial mucus do for kayaking in rough water? Surf boarding?

It is even possible that swimmers could benefit from an artificial mucus. One could design a wet suit that exuded mucus and thus, increase the efficiency of swimming. One would have to take care that the wet suit gloves and the underside of the feet of the swim fins on such a suit were provided with anti-slip properties to ease the task of getting in and out of the water without slipping or falling.

Any anti-drag artificial mucus should include, amongst its other properties, environmental friendliness. It should be non-toxic and non-irritating to sea life as well as humans, degrade quickly in fresh and sea water, and be manufactured from renewable resources.

Because nudibranchs (sea slugs), corals, kelp, and many other marine and freshwater organisms possess mucus on their external surfaces, their mucus should also be examined for desirable properties.

In the future, will Olympic swimmers be checked for mucus lubricants prior to a race? Will the next America Cup race yachts be extra slippery and fast? Biodiversity has many models and lessons for those able to learn!

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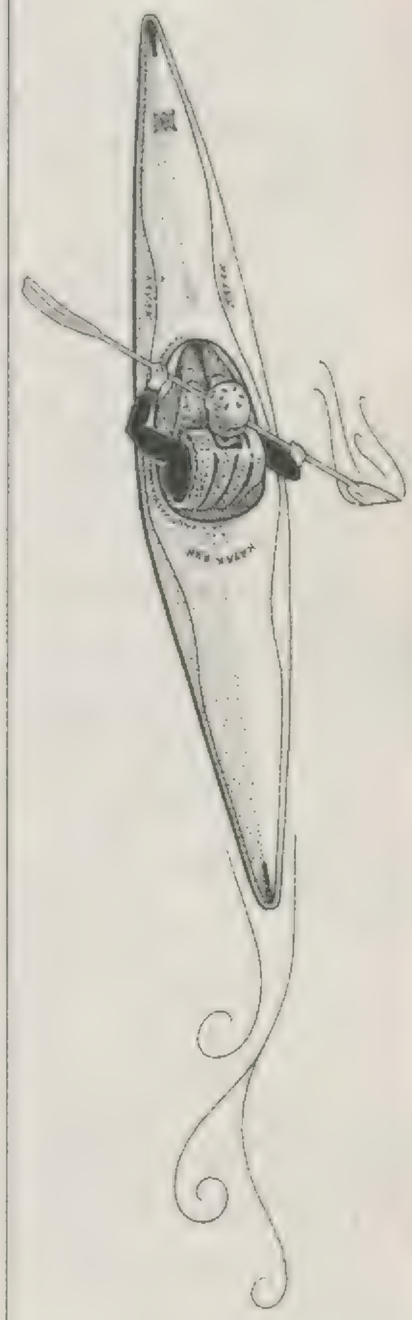
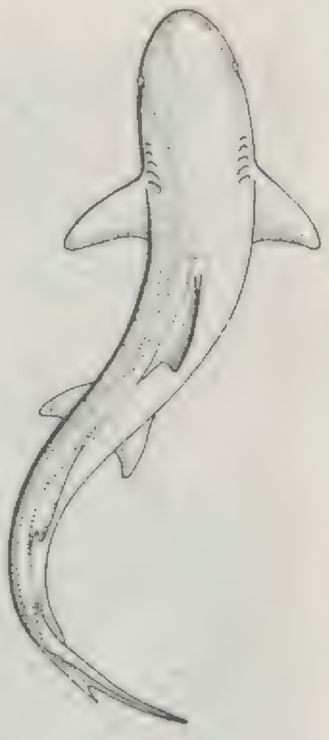




Biodiversity News Notes

BioNET-International Consultative Group proposes network to link systematists with agriculturalists in the South for integrated pest management

The BioNET-International Consultative Group (BICG) was established at the First BioNET-International Consultation held at the Natural History Museum, London on 12 June 1993. It was attended by 50 delegates from 17 countries including representatives of eight sub-regions of the developing world. The following is taken from its initial draft report:

Dr. M.S. Swaminathan graciously accepted to be Chairperson of the Consultative Group and Professor Tecwyn Jones was unanimously appointed as Chairperson of the BioNET-International Coordinating Committee. For complete information on BICG's membership, mission, organization, objectives, and recommendations, the reader should write the technical secretariat at TECSEC Office, CABI, 56 Queen's Gate, London, SW7 5JR, UK, Tel.: (071) 584-0067, Fax: (071) 581-1676, E-mail: CABI-IIE@CGNET.COM

Photograph of BioNET-International Conference attendees. The conference led to the formation of a network that will use the knowledge of biosystematics to reduce the loss of crops and forests in the South from pests. Precise identification services by biosystematists will help avoid the spread of pests from one region to another and permit the use of biological controls and integrated pest management. (Photo by Don McAllister.)

The need for BICG arose for two main reasons: 1) biosystematics is key to identifying and effectively reducing pests on crops in the developing world, and 2) resources are limited in biosystematics both nationally and globally.

Biosystematics–the branch of science concerned with identifying, naming, and classifying organisms and hence, providing the key to all that is known about them–is the foundation for all scientific, biological endeavors. It is the logical basis for the development and implementation of genetic resource management in all its forms, where technically sound and rational decisions are imperative for success. It is a requisite of all ecological inventories and monitoring exercises needed to enable sustainable use and conservation of biodiversity.

The continuing inadequacy of resources and services to support biodiversity management in developing countries constrains and frequently precludes these countries from fulfilling their commitments to Agenda 21 and the Biodiversity Convention of UNCED. The lack of resources for research in arthropods (insects and mites), nematodes (plant parasitic worms), and microorganisms (fungi and bacteria) are particularly critical. They deny the development and implementation of integrated pest management to reduce and prevent pest-induced losses of crops and stored commodities; the enforcement of effective plant quarantine to facilitate trade and the safe transfer and exchange of germplasm; and the diversification and improvement of agricultural and forestry production and sustainable development.

Experience has shown that the biosystematic needs of individual developing countries can rarely be satisfied by their own financially constrained technical resources, or by contracting out biosystematic work piecemeal to developed country institutes, or by a combination of both. The BICG, therefore, seeks the means to mobilise and pool the existing biosystematic capabilities of institutes in developing countries, and to strengthen and sustain them through the transfer of skills, knowledge, information, and material resources. The transfer will take place through BioNET-International.

BioNET-International is conceived as a global biosystematic network composed of sub-regional Technical Cooperation networks or LOOPS linked together. Then through a central Technical Secretariat (TECSEC), the LOOPS are linked to a consortium of technical support institutions (BIOCON) in developed countries. Its present emphasis on arthropods, nematodes, and microorganisms is without prejudice to its ultimate dimension.

Funding is being sought in developed countries to implement the network, to provide for training and other requirements of BICG. Nineteen recommendations were made to the governments of both developing countries and developed countries and also to international organizations and donors, concerning world centres of biosystematics and the support for BICG.

It is encouraging that practical working links are being established between North and South, between biosystematics in the world of science and the agronomists and farmers in the agricultural world so soon after the Earth Summit. This promises to increase the amount of food and supply better nutrition while reducing, through prevention and integrated pest management, the load of pesticides on beneficial soil biota and the off-farm and off-tree plantation natural environment. All the participants, and especially Professor Tecwyn Jones and Dr. M.S. Swaminathan, are to be deeply congratulated.

The Annual General Meeting of the Canadian Committee of IUCN—The World Conservation Union—(CCIUCN) meets at the Canadian Museum of Nature on 8 May 1993

The Chairman, Jacques Prescott, reported that David Munro has carried out a feasibility study on the establishment of an IUCN office in Canada. The proposal had been discussed earlier, and an offer has been made by the Union québécoise pour la conservation de la nature (UQCN) to house this office in Montreal.

Dr. Prescott reported on his attendance at the Earth Summit in Rio de Janeiro and on visits in March 1993 of Dr. Martin Holdgate, Director General, IUCN and Jeffrey McNeely, Chief Conservation Officer, who gave a well-attended lecture at the Canadian Museum of Nature.

David Runnalls, North American Councillor, indicated that the next meeting of the IUCN Council (since held in Gland, Switzerland on 22-27 May 1993) would be a crucial one for the IUCN with a number of critical issues coming to a head. Several changes of senior officers are expected in the coming year, and there is a need to prepare for the upcoming General Assembly that will be held in Buenos Aires in early 1994. Mr. Runnalls also reported on the process and nominations that have been received for the post of President of IUCN, which is up for election at the next General Assembly. It was also reported that Dr. Martin Holdgate wishes to step down in April 1994.

A proposal from the city of Montreal to host the IUCN 1996 Triennial General Assembly in Canada was received. The meeting endorsed the Montreal proposal and urged the Honourable Jean Charest as the then minister responsible for Canada's state membership in IUCN to issue a formal invitation to this effect. It was also suggested that CCIUCN provide a process for dialogue within the conservation community prior to the General Assembly.

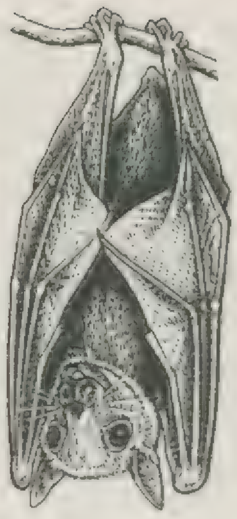
Mr. Richard Laing, Biodiversity Convention Office, presented the work that he is in charge of. Reporting to the Canadian Council of Ministers of the Environment, the Convention Office is to draft a Canadian Biodiversity Strategy in fulfilment of Canada's obligations under the Biodiversity Convention, which Canada has recently ratified (For more, see article on pages 4 - 5).

Three new members were elected to the Board of Directors of CCIUCN: Pierre Gosselin, president, UQCN, William A. Rappley, Executive Director, Metropolitan Toronto Zoo, and Bruce Amos, Director, National Parks System Branch, Parks Service, Environment Canada. They replace George Greene, Harvey Mead, and Ian Rutherford whose terms expired at this meeting.

I.D. Rutherford, Secretary (1992/93), C.C. I.U.C.N.

Will climate change affect sex ratios?

The Galapagos Bulletin (Winter/Spring 1993) states that it is well known that egg incubation temperatures determine the sex in some groups of reptiles. In the



Galapagos tortoise rearing centre, experiments at high temperatures produced females and at low temperatures, males. Eggs incubated at temperatures between 28.5° and 29°C produced two females for every one male.

This leads to the question of whether or not global warming will change the ratio of male and female tortoises or other reptiles. An imbalance in the natural sex ratio could produce genetic effects (an important function of sex is the mixing the genes of successful parents, increasing survivability of offspring) or it could result in different numbers of young being produced and imbalances between available habitat and number of individuals. Will global warming affect species other than reptiles? (D.E.M.)

New American ballast water regulations to prevent introduction of exotic species go into effect

New U.S. Coast Guard regulations require that freshwater ballast must be exchanged at sea before entering the Great Lakes, or they must retain it on board. The new rule went into effect 8 May 1993. The new rules are designed to prevent the introduction of exotic freshwater organisms into the Great Lakes. The saltwater organisms imported in sea water would not survive in the Great Lakes. These rules apply to ships that operate outside of the 200-mile offshore limits of the United States and Canada. [*Ottawa Citizen,* 10 April 1993].

While the new rules protect against the introduction of freshwater species into North America, they ignore introduction of marine species from one part of the world to another. Already many species have been introduced in this manner and many ports with international shipping now harbour exotic species, which subsequently may disperse along the coast. (For more, see article on pages 17-18.) Some species have a great potential for damage. Outbreaks of the crown-of-thorns starfish, *Acanthaster planci,* have caused great damage to coral reefs in its native Indo-Pacific range. (See 1987 Sea Wind 1(1): 6 and 1(4): 24.) Transport of the larvae or young in ballast water might have unfavourable effects on Caribbean coral reefs. Protection against the transport of marine species could be obtained by requiring transport of freshwater ballast water.

Oldest fossil bee is discovered

A 50 million-year-old fossil bee has been discovered in Germany. The fossil, found in rock from the Eifel region, is the oldest fossil bee ever found. The ancient bee differed only slightly from modern ones [*Ottawa Citizen,* July 1993]. The find sheds light on the evolution of plant pollination; bees are one of several groups of insects that provide pollination services to plants, essential to make seeds fertile.

Bat species disappearing

Nearly 40% of American bat species are threatened or endangered, and around the world, many more are declining at alarming rates. Many wild and important agricultural plants including bananas, cashews, dates, and figs rely on bats for pollination or seed dispersal (*Cranbrook Institute of Science Newsletter,* July 1993, 63(1): 4). For more information on the status of bats read Brock Fenton's article "Bat biodiversity" in *Global Biodiversity* 3(1): 4-6.

Irwin Brodo of CMN receives 1993 Mary E. Elliot Service Award of Canadian Botanical Association

Dr. Irwin Brodo, research scientist in lichenology at the Canadian Museum of Nature, received the 1993 Mary E. Elliot Service Award at the August annual meeting of the Canadian Botanical Association (CBA). The award is given annually for meritorious service to the CBA. Dr. Brodo has been a member of CBA for thirty years and has served in numerous capacities. His service has included membership on the CBA's Systematics and Phytogeographics Committee, the Science Policy Committee, Presidency, and representation of CBA on councils such as the Canadian Biological Association.

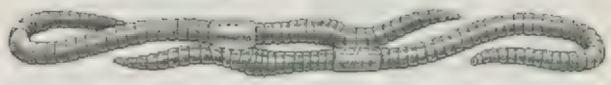
Positions sought in systematics and collections management

Due to reorganization at the Canadian Museum of Nature, researchers and collection staff are seeking employment. Expertise includes general invertebrates, malacology, ichthyology, herpetology, ornithology, mammalogy, vertebrate ethology, paleomycology, bryophytology, vascular plants, crystallography, gemology, education, display, and library. Interested parties may phone the Museum's resource centre at (613) 991-1839 or fax (613) 991-0117.

Global biodiversity salutes the 30 nations that have signed the Biodiversity Convention

Canada
China
Mauritius
Marshall Islands
Seychelles
Maldives
Monaco
St. Kitts and Nevis
Ecuador
Fiji
Antigua and Barbuda
Mexico
Papua New Guinea
Vanuatu
Cook Island
Armenia
Guinea
Zambia
Peru
Norway
Japan
Australia
Uganda
Tunisia
Saint Lucia
New Zealand
Belarus
Burkina Faso
Bahamas
Mongolia

The Convention will come into force on 29 December 1993, 90 days after Mongolia became the 30th country to ratify the Convention.



Biodiversity Meetings

4-5 JANUARY 1994.

Canadian Conference for Fisheries Research. To be held at the Delta Bessborough Hotel, Saskatoon, Saskatchewan.

Contact: R.J.F. Smith,
Biology Department,
University of Saskatchewan
Saskatoon, Saskatchewan S7N 0W0

18-26 JANUARY 1994.

19th Session - IUCN General Assembly: "Caring for the Earth and its People." To be held in Buenos Aires, Argentina.

Contact: Telephone: (41 22) 999 01 15
Fax: (41 22) 999 99 10

22-26 JUNE 1994.

Sustaining the Earth Summit: Planting a New Vision of Sustainable Agriculture. To be held in Minneapolis, Minnesota.

Contact: International Alliance for Sustainable Agriculture (IASA)
1701 University Avenue SE,
Minneapolis, MN 55414, USA.
Telephone: (612) 331-1099
Fax: (612) 379-1527

28 AUGUST - 3 SEPTEMBER 1994.

Measuring and Monitoring Biodiversity in Tropical and Temperate Forests. To be held in Chiang Mai, Thailand.

Contact: Secretariat, Forest Biodiversity Symposium
Royal Forest Department, Silvicutural Research Subdivision
61 Paholyothin Rd., Chatuchak,
Bankok, Thailand 10900
Fax: 66-2 5794730 or
Fax: 1-819-997-8697

Book and Periodical Niche

The biodiversity of microorganisms and invertebrates: Its role in sustainable agriculture

Edited by D.L. Hawksworth. 1991. C.A.B. International,
Wallingford (U.K.). xx + 302 pages. ISBN 0-85198-722-2.
HB £40.00 (US $76.00 Americas only)

This nicely produced volume records the proceedings of the First Workshop on the Ecological Foundations of Sustainable Agriculture, held in London, 26-27 July 1990. The aim of the Workshop was to "review what is known of biodiversity among invertebrates and microorganisms, to assess how agricultural and other changes are affecting it now, and may affect it in the future, and to make recommendations about what actions need to be taken by scientists and governments to improve knowledge and determine future actions." But do not be deceived by the cheerful "Mary Kay" pink covers: there is very little between them to be cheerful about.

Agriculture covers 25-30% of the world land area and is the prime cause of simplification of the environment's structure: it replaces natural diversity with only a few cultivated plants and domesticated animals. Only about 70 species of plants occupy 1440 million hectares of cultivated land. Contrast this with a single hectare of tropical rain forest, which may contain 100 species of trees alone. Tropical forests have now been reduced to about 6% of the land area (from a 12% prehistorical value) but still contain at least 50% of the Earth's species.

The simplification of diversity in agro-ecosystems has brought into sharper focus the prevalence of invertebrates and microorganisms, and their intimate link to the function and stability of communities and ecosystems.

Historically, the invertebrates, but especially microorganisms, were misunderstood by our species; we relegated them to a rank of inferior or "lower" form of life, and still tend to see only the sinister side of their existence as competitors and foes. It is true that microbes more easily adjust to adversity and easily beat us at the game of survival. Because of that superiority and its use in the "arms race," microbial diversity may in fact be increasing in some cultivated areas. However, the impression that invertebrates and microorganisms can look after themselves is dangerous, especially if it leads to a notion that there is no need to preserve their diversity. It cannot be overstated that microorganisms can exist without us, but we cannot exist without them.

▪ *It cannot be overstated that microorganisms can exist without us, but that we cannot exist without them.*

Why does our species need to preserve diversity of invertebrate and microbial competitors? The very survival of *Homo sapiens* depends on our ability to live within the current budget of solar energy, and not off the fossil inheritance. And since food is the critical commodity, an important priority now facing us is the achievement of sustainable agriculture. By this is meant self-sufficiency in terms of soil fertility, crop protection, and crop productivity. This can only be done with the help and cooperation of microorganisms. The importance of microbiota in maintaining soil fertility is well summarized in the quote: "When devoid of its biota, the uppermost layer of earth ceases to be soil."

Much of the book dwells on the second prerequisite of sustainable agriculture: crop protection. The reckless use of chemicals to control pests and diseases must give way to promotion of natural enemies, and polyculture as opposed to clonal monoculture. When natural habitats become increasingly fragmented "in a sea of cropland," the reservoir of natural enemies decreases–before even the most basic knowledge of their diversity, and understanding of their biology had been glimpsed.

Then there is the question of productivity. Consider this example: Half of the world's population depends on rice. In 1988, 145 million hectares of land yielded 468 million tonnes of rice. A projected additional 300 million tonnes will be needed in 2020, a 65% increase in less than 30 years! It is a tall order for agriculture, which is heavily subsidised by the planet's capital of energy. It is a sobering thought that this demand on productivity is to be achieved in a sustainable manner, and without further erosion of natural habitats. To meet this expectation, and parallel demands on other staple crops, agriculture needs to increase the present base of 150 commercial crop plant species from the natural reservoir of 250,000 while they still exist.

Furthermore, agriculture will need to modify the existing cultivars, or even "engineer" new ones, by tapping nature's genetic diversity, while it still exists. The greatest pool of genetic diversity lies among the invertebrates and microorganisms of forests and grasslands. Most of it remains to be quantified, even approximately. Only about 69,000 of the estimated 1.5 billion species of fungi, 800,000 of at least 6 billion insects, only about 3% of 500,000 nematodes, and a similar proportion of bacteria and viruses have been described. And only in a small fraction of these (scarcely 1% of the named invertebrates) have the life cycles been elucidated and their biology understood. "On this base of ignorance we are planning our future occupation and development of the planet Earth. Any business plan which included such a market evaluation would be seen as quite unacceptable by even the most insensitive investor."

A repeated appeal is made for high priority funding of taxonomic research and training. There is a need for consolidation and integration of information from diverse interdisciplinary sources. Names of organisms serve as access points in information retrieval. There is, however, less confidence in the relevance of this information to the understanding of biodiversity. "The morphological species concept is clearly a subjective and arbitrary one. Thus, measures of diversity based on it must also be to some extent subjective and arbitrary." The use of microbial "biotypes" often "provides falsely simple solutions to complex problems." Examples from plant pathology, medical and veterinary entomology, etc., show that conventional taxonomy regularly underestimates levels of genetic diversity.

Undoubtedly there is a critical need to support and expand biosystematics to obtain the "first approximation" of biodiversity, but the approaches need to be expanded if this crucial discipline is to regain prestige. There is a detectable shift of attention to the genome as the foremost appropriate unit of diversity, especially among molecular geneticists, who may well shape agriculture in the 21st century. In the meantime, biosystematics continues to decline. Each year fewer than 10,000 species of invertebrates are described, a minute dent in the vast body of at least 6 billion more "awaiting discovery." Except that organisms no longer wait. An estimated 17,500 to 35,000 are lost each year forever.

Much attention is given to the loss of the visible animals and plants, but the "actual losses in numbers of species are likely to be much greater among the less readily observed invertebrates and microorganisms living in the soil and within the forest canopy." Considering the limitations of both human and financial resources currently available, "it is unrealistic to assume that all existing microbial resources will ever be preserved. Priorities, therefore, must be established."

Some options, e.g. preservation of "key species," "key areas," or the establishment of culture collections, offer only a selective partial remedy. How well can we identify key organisms or areas on the basis of our present knowledge of microorganisms and understanding of their biology--if at all? We can keep specimens of only a fraction of the existing diversity, and only by isolating the organism from its immediate biological environment with which it may be in dynamic interaction.

Forty years ago, Aldo Leopold (1953, *Round River*, Oxford University Press) gave this advice: "If the biota, in the course of aeons has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering." Thirty-six years later, the International Union for the Conservation of Nature and Natural Resources (IUCN) concluded that "conserving biological diversity equals conserving ecosystems"; that the only effective conservation of the undiscovered potential is by conservation of ecosystems. Increasingly, of course, genetic diversity can be stored artificially as nucleic acid sequences, and gene banks should supplement efforts to preserve natural habitats.

This book was not meant to prophesy doom, nor was it intended to capitalise on the woes facing humanity. It is a dispassionate, sometimes technical, scientific disposition. But because it is dispassionate, the book strikes closer to home and with greater urgency. Time is running out for voicing concerns, drawing resolutions, testing policies, or even setting priorities. Humanity has reached a point when it will have to make choices. The choices will be painful as well as difficult, because conservation of biological diversity must be considered "in human terms and not just in its taxonomic and genetic dimensions." How difficult is the choice between the spotted owl or 30,000 jobs? How much more agonizing will be the choice between saving a stretch of rain forest in Africa or the estimated 6-7 million children who die of malnutrition and disease before they reach the age of five?

Kris A. Pirozynski, 273 Roger Road,
Ottawa, Ontario K1H 5C5, CANADA

Re-Introduction News

Newsletter of the Re-Introduction Specialist Group of IUCN's Species Survival Commission (SSC). Contact: c/o African Wildlife Foundation, P.O. Box 48177, Nairobi, Kenya, Tel. (254) 2-710367, Fax: (254) 2-710372.

The following is a review of the No. 6, May 1993 issue of the newsletter. The 12-page newsletter contains the following sections: Letter from the Chairman, Recent Meetings, Upcoming Meetings, Re-Introduction Updates, Re-Introduction Briefs, and New Literature. Most of the newsletter is given over to Re-Introduction Updates. Introductions include the successful re-introduction of Common Dormice into grounds of Haileybury College, southern England; the release of Orinoco Crocodile in Venezuela; the follow-up on the successful re-introduction of the Arabian Oryx; re-establishment of Mallorcan Midwife Toad populations in the north of Mallorca (this species was only discovered in 1980 and populations have been declining); the development of micropropagation techniques for the Australian plant, *Corrigin grevillea,* one of the 239 threatened plants in West Australia (8,337 plant species have been named to date and a large proportion of the flora is endemic or native to this area); and the release program for the Andean Condor in Venezuela. The Re-Introduction Specialist Group is obviously energetic and successful in the reported projects, battling impacts of world-wide habitat loss and extinction.

Don E. McAllister, Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4, CANADA.

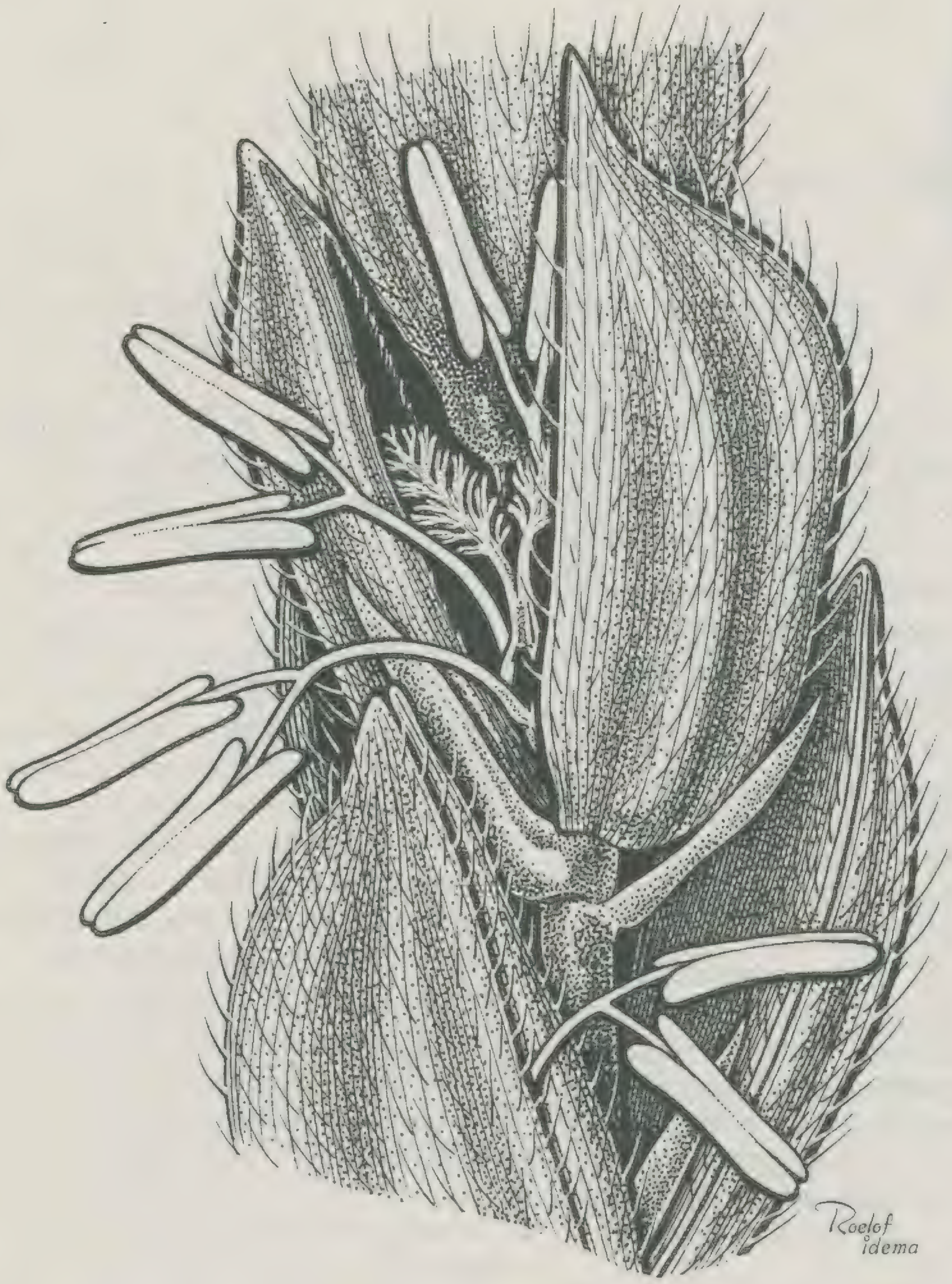
Europal

A biannual revue edited by the European Palaeontological Association, No. 2, October, 1992, *"Les collections paléontologiques en Europe: passé, présent et futur,"* by Jacques Thierry, Dijon, France, pp. 15-21, feature article. Each issue 50FF, ISSN 1019-0724.

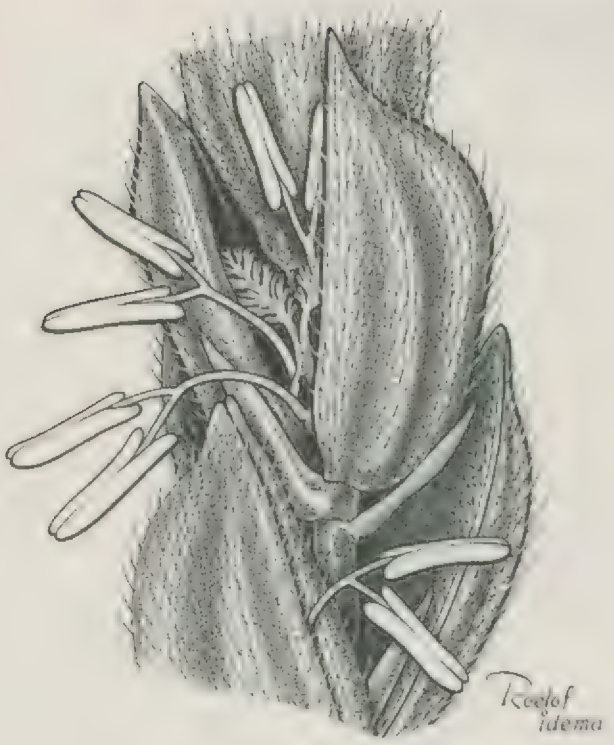
Paleontological collections in Europe are quite diverse in three major ways. The diversity appears in terms of which level of government supports them (civic, regional or national), which level of society supports them (royal, religious or civil), and the interests current at the time they were founded. Collections blossomed during the discovery and exploration of the new world and in the period of colonial expansion. During recent periods of war and economic reversal, collections have fallen into decay because collections personnel (usually with scientific-academic backgrounds) have been reduced in number and overwhelmed with responsibilities to the public. In the case of individual researchers under such conditions, the integrity of cataloguing has taken second place to academic contributions.

Of extreme importance is the maintenance of type and figured specimens, wherever they may be housed. Type specimens are key specimens to which a scientific name is tied; figured specimens are simply those that are illustrated. In 1983, under the patronage of the Ministry of National Education, the French Paleontological Association began to assemble a data bank on type paleontological specimens in France (termed TYFIPAL after "*TY*pes et *FI*gurés en *PA*Léontologie") under the scientific supervision of Jacques Thierry (the author). Data gathering was standardized and included 14 individually addressable descriptors plus information on the subsequent fate of a name that was based on a particular specimen. More than 50 French institutions have provided data for 55,000 type and figured specimens, and work on the data bank continues. A map depicts the number of institutions preserving paleontological collections throughout Europe. Other European countries have expressed an interest in TYFIPAL, raising hopes for an eventual European data bank on the most important part of its paleontological heritage and for safeguarding that heritage into the future.

Dale A. Russell, Research Scientist, Paleontology, Canadian Museum of Nature, Ottawa, Ontario, CANADA.



Rice
Oryza sativa



Rice

Oryza sativa

In Sanskrit, there are two terms for rice; one of them translates as "sustainer of the human race." Certainly, rice does sustain much of the world's population. Half of the people on Earth, including almost all of East Asia, are dependent on rice as a staple food.

Oryza sativa, or white rice, is one of 20 species of Oryza (grass family Poaceae) whose origin has been traced back approximately 2,500 years ago to the Nepal-China area. The African *Oryza glaberrima*, a second cultivated species, probably originated 3,500 years ago in West Africa. An annual grass, *O. sativa* grows to one metre in height and is topped by a panicle, or a loosely branched flower cluster, the seeds of which become the familiar rice. The seeds are sown in prepared beds, and when the seedlings are between three and six weeks old, they are transplanted to a paddy. Because *O. sativa* is a wet-rice species (some varieties are cultivated on dry soil), it needs to be grown on submerged land. Paddies are usually enclosed by levees and are irrigated to submerge the land under 5 to 10 cm of water. Before harvesting, the paddies are drained. Byproducts of milling, including paddy straw, bran, and rice polish (a starch) are used as livestock feed.

As with all agricultural crops, weeds and pests present problems. The quality of soil is also of paramount importance. Blue-green algae, which can fix atmospheric nitrogen, often are present in rice paddies. This reduces the need to apply nitrogen fertilizers. Fish species, which provide valuable protein, are also grown in paddies and may help contol some pests.

The genetic diversity of plant crops is important in productivity and the resistance to pests and diseases. Genetic enrichment sometimes occurs when introduced crops encounter and cross with wild varieties. For example, in West Africa, an indigenous cultivated rice, *O.glabberima* has been hybridized with the common Asian rice, *O. sativa*, enriching the gene pool in the region (Groombridge, 1992, Global Biodiversity, World Conservation Monitoring Centre, p. 331). Gene pools are also modified by intentional human and natural selection to suit crop environments, enhance nutritional qualities, taste, productivity, and pest resistance. This can be achieved by farmers developing local land races, by crop scientists, or seed companies drawing desirable genetic characteristics from stocks in seed banks. The International Rice Research Centre in the Philippines coordinates the collection of indigenous varieties.

In some circumstances, genetic variability may be reduced by development agencies or seed companies. The rice variety, which gave rise to the Green Revolution, was introduced widely in Asia and supplanted many local land races. The intent was to increase production through higher yields. A measure of this goal was achieved, but this variety also required more fertilizer; also, the widespread use of a uniform variety led to the need for more pesticide application. Poorer farmers, therefore, could not afford to grow that variety. Older rice varieties that are adapted to local conditions and local peoples' needs are often lost through replacement by modern highly-bred cultivars promoted by corporation marketing or development agencies. This genetic erosion threatens a crop that feeds half the world. *(Noel Alfonso, Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa, Ontario, Canada)*

Mycorrhizas in ecosystems

Edited by D.J. Read, D.H. Lewis, A. H. Fitter and I.J. Alexander. 1992. C.A.B. International, Wallingford (U.K.). xvi+419 p. £55.00 (US$104.50).
ISBN 0-85198-786-9.

This book comprises texts of 48 papers and abstracts of 61 posters presented at the 3rd European Symposium on Mycorrhizas held at the University of Sheffield in August, 1991.

Not so many years ago, "mycorrhiza" (which means "fungus root") was a term familiar only to the initiated few within the ranks of biology. In the last two decades students of this association of fungi with roots of plants have made spectacular advances. Not only did they establish a new scientific discipline, they succeeded in alerting the general public to the importance of root symbioses in enhancing growth of individual plants and in structuring of their communities.

The study of mycorrhizal symbiosis is a young discipline. It is still dominated by pioneer investigators who staked out individual claims and territories and guard them with determination. The mycorrhiza meetings tend to attract the same people, saying much the same thing, and citing the same work, mostly their own. In this book there lingers the feeling of déjà vu, a hint of staleness, and of conceptual inbreeding. But there is one welcome change. The meeting attempted to shift the emphasis from the laboratory to "mycorrhizal functioning in nature." Predictably, the picture that emerges is not of a simple one-to-one interaction but of a complex symbiosis of mycorrhizas with the living soil. For example, it is becoming clearer that the functioning of mycorrhiza may, in some cases, be controlled by soil bacteria. Fuller understanding of such seeming details is critical to the understanding of natural communities of plants on which will depend our success with conservation of the existing ecosystems, and regeneration of the lost or degraded ecosystems, including tropical forests.

The text is competently assembled and edited, and the book is well produced. The editors anticipate that the volume will serve those who wish to gain a more complete understanding of the functioning of natural ecosystems, but most of its narrowly focused individual contributions are aimed at a professional. This will likely place the book beyond the reach of lay naturalists' interests and, with the price tag of about Can$140, outside the reach of their pocket books, too. However, this book should be assured a place in every library serving those whose interest is in the issues of environment and biodiversity.

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Balancing act: Environmental issues in forestry

by Hamish Kimmins, 1992, University of British Columbia Press, Vancouver, B.C., Canada, 256 p.
ISBN 0-7748-0426-2 PB. $29.95;
ISBN 0-7748-0435-1 CL. $45.95

Dr. Hamish Kimmins has presented a clear and easily understood description of the challenges, complexities, and problems facing forestry in today's climate of environmental awareness and concern.

The opening chapters provide excellent descriptions of various aspects of forest management, which should serve two purposes: a refresher and update to the practising forester, and a concise and understandable introduction to forestry for the lay person. Dr. Kimmins goes to great lengths to present a balanced and even description of the issues and makes every effort to expose the myths and generalizations put forward by both sides in the forestry/environment debate.

Traditional forest managers should find the book useful and informative, not only for its comprehensive discussion of forestry but also for its exploration of broader issues and its consideration of some justified criticisms. Staunch environmentalists may not accept the book because it exposes their long held and scientifically weak arguments, which have been used to justify their positions on many forestry issues. The "average person" should come away with more of an understanding of the complexity of forest ecosystems, the numerous options and consequences of various actions, and a better appreciation for the absolute nonsense of simplistic generalizations.

The book tackles the major issues in well-defined chapters that deal with subjects such as clear-cutting, slash burning, the use of chemicals, old growth forests, biodiversity, acid rain, climate change, and other topical and sensitive areas. Each chapter begins with an overview and concludes with a summary, both of which serve as quick and useful references for the particular

subject with which the chapter deals. This approach does, however, result in some repetition, as does the chapter-by-chapter description of topics that were introduced or briefly discussed in the earlier introductory chapters. The repetition, however, is compensated by the more complete coverage each issue is afforded. This allows the reader to focus on subjects of particular interest while paying less attention to other areas and still get a fairly complete description.

Balancing Act combines the obvious expertise and scientific background of the author with a very readable and nontechnical writing style. The book does tend to focus extensively on British Columbia, however, and the photographs (all black & white) are not as useful as they might have been. Illustrations would have been clearer and helped to explain complex concepts much better.

Despite the favourable reception most environmentalists gave to Herb Hammond's book *Seeing the Forest Among the Trees,* I found Dr. Kimmins book much more balanced in its approach, more informative, and much less of a religious fundamentalist's sermon, which is what Hammond's book reminded me of. *Balancing Act: Environmental Issues in Forestry* should be closely read by foresters, environmentalists, and anyone who is interested in the forestry/environment debate. It should give everyone the basic background they need to understand and eventually resolve the conflicts that these debates are generating.

C.A. Lee, R.P.F., Executive Director, Canadian Institute of Forestry, Ottawa, Ontario, CANADA.

WHAT'S A TREE WORTH TO THE AVERAGE URBAN AMERICAN?

An excerpt from *Trees of Life*

Exactly what are privacy, shade, bird-nesting sites, and a welcome break from asphalt worth anyway? The value of some forest uses is difficult to calculate in dollars. But some efforts along these lines have been attempted. According to the American Forestry Association (AFA), the United States' 70 million or so acres of urban tree spaces are worth more than $50 billion. As for a single tree, in 1985 AFA's Gary Moll estimated that an average 50-year-old city tree would provide $73 worth of air conditioning, $75 worth of erosion and storm water control, $75 in wildlife shelter, and $50 in air pollution control in one year. Adding a little for inflation, Moll calculated the worth of a single urban tree over its half-century lifetime at $57,151.

Assessments like these aren't lost on real estate agents. Property with trees commands higher prices than property without them, all other things being equal. Older, larger trees are prized most, but, according to the U.S. Forest Service, suburban homeowners can boost property values by up to 20 percent–an average increase of $3,000–by adding trees to their lot.

Growing concern about the greenhouse effect and global warming may also increase the value of the trees. Because trees shade buildings, they decrease the need for air conditioning, which decreases the use of electricity, much of which is derived from fossil fuels–main sources of greenhouse gases that contribute to global warming. AFA estimates that planting more trees in cities could shave $4 billion a year from national energy costs. Even three strategically placed trees around a house can cut home air conditioning costs by from 10 to 50 percent.

Trees of life: Saving tropical forests and their biological wealth

By Kenton Miller and Laura Tangley. 1991.
World Resources Institute; Beacon Press, Boston, MA,
ISBN 0-8070-8508-1 (cloth). ISBN 0-8070-8505-7 (pbk).

Few of us living on this planet today, who have access to a radio or television, have not heard of the global disastrous effects of acid-rain, tropical deforestation, and the greenhouse effect. Certainly the media cover these and other environmental issues nearly daily. Yet, all too often these short "takes" leave the average person bewildered, confused, or even discouraged.

In their book *Trees of Life* Miller and Tangley have provided an alternate approach; there is still a chance to redeem what we've already lost in our environment, and concerned individuals can make a change toward saving our rain forests. These alternatives form the basic theme of this excellent and well-written book. While the authors clearly admit that the fate of the world's remaining tropical forests depends largely on government policy and the influence of environmental organizations such as IUCN, WWF, and UNEP, they nonetheless encourage individual support, closer to home, to initiate the change.

This book is a guide. It acts as an outline and provides an overview of the causes and effects of rainforest degradation and deforestation. When appropriate, it suggests solutions to major environmental problems. The authors suggest "a quantum leap in knowledge and a transformation in values...an almost revolutionary change in how we view nature."

Trees of Life is one of the "biggest" smallest books I've read on the subject of saving our tropical forests. The authors have literally packed the seven chapters with hundreds of facts and figures on the current (and past) diversity, use, management, and future of our world's forests. For example, in the chapter on "What have we got to lose?" nearly every page contains details on what the forest means to us, what we've already gained through a better understanding of tropical ecosystems, and also what has been lost. Species extinctions today may be the highest they have been since the global mass extinctions 65 million years ago!

The book stands apart from other similar books in that the authors have provided answers to our questions of "what is being done to save our forests?" and more importantly, "what can we do?" (Chapter 7).

Two appendices follow the chapters; one lists American organizations that can help, providing addresses, phone numbers, and a brief description of the mandate of each organization. The other appendix is a short essay on forests and genetic diversity.

Trees of Life could help "armchair" environmentalists interpret local and national media coverage of environmental issues and problems. It may provide a basis for re-thinking our "green attitudes" or our understanding of good and evil.

The final words of this review are left to the authors:

> *"According to Genesis, naming the animals in the Garden of Eden was one way in which humanity asserted dominion over all other creatures. Sadly, many species are now dying nameless, and names may soon be all that is left of others."*

David M. Jarzen, Research Scientist, Canadian Museum of Nature, Ottawa, Ontario, CANADA.

Is the extinction crisis real?

By Paul R. Ehrlich. 1993. Wildlife Conservation 96(5): 66-67.

This bioessay responds to a *New York Times* Op-Ed column that challenged the reality of the extinction crisis. The bioessay reaffirms that the rate of extinction is high due to loss of habitat and the specialized habitat requirements of species, e.g. soil, climate, and food. The existence of significant species extinctions is not in dispute amongst most biologists. Indeed for certain groups, it is well documented. The number of species being lost per year can only be approximately estimated: "If Earth contains, at a conservative estimate, 20 million species, that will mean a loss of about 100,000 species, each year; by the end of the century, roughly one million species. On the other hand, if (as some scientists are convinced) there are 80 million species, one million is a vast understatement of the extinction problem." According to Erlich these facts call for an active program in protected areas and also, outside protected areas. Protected areas in themselves will not adequately preserve genetic variability or the ecological services required by the planet, let alone all the economic activities derived from the planet.

Don E. McAllister, Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4, CANADA.

The keystone-species concept in ecology and conservation

By L.S. Mills, M.S. Soulé and D.F. Doak. 1993.
BioScience 43(4): 219-224.

This article criticizes the usage of the term *keystone species* because of the varied meanings assigned to it. Keystone has been applied to predators, prey, hosts, essential supporting species (e.g. pollinators), and those that create habitat. Hallmarks of keystone species have been their crucial role in maintaining the organization and diversity of their particular ecological communities. The extent of this role is exceptional, relative to the rest of the community. The few studies done suggest that removal of keystone species results in disappearance of at least half the assemblage of species considered. However, food-web theorists generally assume that species by species interactions are normally distributed, rather than skewed. This suggests that keystone species don't comprise a distinctive cluster but are simply outliers on a curve. Evidence is slender and ambiguous.

The keystone species have been discussed as the possible focus of conservation efforts. But Mills *et al* (1993) warn against the application of the keystone concept in conservation programs until keystone species are clearly defined and the concept is established on a firm data footing. Instead they advocate that study focus on interaction strengths and the application of the results subsequently be made into management plans and policy decisions. They believe this would more explicitly account for the complexity of natural systems, in spite of losing the evocative concept of the keystone species, which is easier to communicate with policy makers, managers, and the public.

Don E. McAllister, Canadian Centre for Biodiversity, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4, CANADA.

Moods of the Ohio moons, an outdoorsman's almanac

By Merrill C. Gilfillan, 1991, Kent State University Press, Kent, Ohio, 44242, cloth $22.00/paper $11.50, 137 pp., ISBN 0-87338-436-9.

A former wildlife biologist for the Ohio Division of Wildlife (Ohio Department of Natural Resources), and editor of the *Ohio Conservation Bulletin* and its successor, the *Wonderful World of Ohio* magazine, Gilfillan very ably took what appears to be "typical" essays on the twelve months of the year and developed them into visible observations of unique outdoor life.

Although the book is written from the writer's observations of changes in nature concurrent with phases of the Ohio moon, it could well have been written in Ontario and still have the same impact. Each month is an essay in itself; so you could choose your "special" time of year and start reading without having read the previous chapter. The book is small but with a large impact, and the message is quite simple. Persons generally observe nature with their attention to the object itself rather than to impressions generated by the object. "Observation is more of the mind than of vision," and the lesson herein is that we receive a greater understanding and appreciation of nature through our observations.

Each essay is ordered similarly, following the weather, diagnostic events, vegetation, birds, mammals, other wildlife, agriculture, and the mood of the month. The author draws upon Indian moon names (North American continent), which were chosen because natives lived with nature, rather than exploiting it. The Indians also had more time to experience nature and their names provided character, or "an eternal essence of the time."

Moods of the Ohio moons is excellent reading with which to renew imagination and spark individuality of observation in nature.

Susan A. Jarzen, Volunteer in Paleobiology, Canadian Museum of Nature, Ottawa, Ontario, CANADA.

The diversity of life

By Edward O. Wilson, 1992, Harvard University Press, Cambridge, Massachusetts, 424 pp, Index, ISBN 0-674-21298-3, $29.95US.

Edward O. Wilson is regarded as one of the internationally renowned leaders of biodiversity studies and his new book *The Diversity of Life* attests to his expertise in this field.

The book is comprised of three main sections. In the first section the author takes the reader on a tour through time, where he shows how nature is both violent and resilient at the same time. Here he reflects on the crucible of life by first describing the violence of a thunderstorm in the Amazon rain forest. He also eloquently relates the return of various forms of life, both plants and animals, on the island of Krakatau after its eruption in 1883. Then Wilson overviews diversity changes during the five great natural extinctions that have occurred through geological times. Again, he emphasizes the astonishing resilience of life in surviving natural catastrophes of epic proportion, such as those caused by meteorites, volcanoes, or other natural phenomena.

In the second section of his book, Wilson explores how biodiversity has risen through the forces of evolution. The formation of species, the result of adaptive radiation, and the creation of ecosystems are treated in this section. In particular, the chapter entitled "The Unexplored Biosphere" reveals to the reader how little we know about the existing diversity of life on the planet. "We don't know the total number of living organisms on Earth, even to the nearest order of magnitude. The number could be close to 10 million or as high as 100 million," Wilson says.

The third and last section of this book deals with "Human Impact" on the Earth's biodiversity. Here Wilson poignantly describes the magnitude of human destruction and suggests that the resulting rapid decrease in the world's biodiversity is the sixth great paroxysm of extinction to have occurred on the planet. According to E.O. Wilson, this latest extinction spasm may be the one that will break the crucible of life.

Wilson relates how the extinction of large mammals and flightless birds around the world coincides closely with the arrival of humans on various continents. The extinction of the moa bird of New Zealand; elephant birds, the *Aepyornis maximus* and many lemuroids from

Madagascar; the famous dodo, fruit pigeons and giant tortoises on Mauritius; and the imperial woodpecker of Mexico are just a few of the well-known examples of extinctions driven by colonists in various parts of the world.

And today, the destruction and the extinction continues with increasing severity. Wilson writes, "Will it ever be possible to assess the ongoing loss of biological diversity? I cannot imagine a scientific problem of greater immediate importance for humanity. Biologists find it difficult to come up with even an approximate estimate of the haemorrhaging because we know so little about diversity in the first place." But, as the author mentions, conservative estimates of the absolute amount of biological diversity vanishing year by year in the rain forests of the world because of clear cutting is estimated at 27,000 species–that is 74 species doomed each day! Staggering numbers though these are, they may well be conservative ones according to the author. Wilson is convinced that, "Clearly we are in the midst of one of the great extinction spasms of geological history."

In his chapter "Unmined Riches," Wilson convincingly shows that a "vast array of other beneficent but still unknown species exist." "Unmined Riches" includes new substances and medicines that cure cancers and various illnesses, new and more ecological plant crops, including nitrogen-fixing legumes that could raise soil fertility and "raise the standard of living of millions of people in the poorest tropical countries." Unfortunately, numerous species, which could be so beneficial to humanity, risk being reduced to extinction before they are discovered or used in large scale by humans in sustainable and environmentally sound ways. Considering the rate of worldwide loss of biodiversity, Wilson cautions, "Still undeveloped medicines, crops, pharmaceuticals, timber, fibers, pulp, soil-restoring vegetation, petroleum substitutes, and other products and amenities will never come to light."

Wilson's book on the diversity of life concludes by describing in detail an agenda aimed at saving and using in perpetuity as much of the Earth's diversity as possible. His plan includes: 1) conducting a survey of the world's fauna and flora, 2) creating biological wealth, 3) promoting sustainable development, 4) saving what remains, and 5) restoring the wildlands. The author closes by addressing the fundamental problem of environmental ethics. Everything in the natural world is interconnected, from the air we breathe, the food we eat, to the importance of wilderness, to the quality of human life. "We should judge every scrap of biodiversity as priceless while we learn to use it and come to understand what it means to humanity."

Well written, poignant, and very instructive, I highly recommend *The Diversity of Life* to conservationists, biologists, the general public, and in fact, anyone who is alarmed at the present worldwide decline in biodiversity on the planet.

André Martel, Research Scientist, Canadian Museum of Nature, Ottawa, Ontario, CANADA.

Better house and planet

By Marjorie Harris. 1991. Key Porter Books Limited, Toronto. 219 pp. paperback $16.95. ISBN 1-55013-257-1. Distributed in the USA by publishers Group West, Emeryville, CA.

This unique household aid has environmental protection aspects, citizen participation suggestions, consumer education on goods and the environment, and over 500 tips for efficient housekeeping. It is a delightful and easy book to use, with topics in alphabetical order from *air conditioners* to *zippers*. Included is also a complete index of referenced topics.

Harris's emphasis is always on advice that works, giving a practical answer for nearly any crisis. Most significant is the "Green House" icon in the margins alongside an environmentally safe alternative to an old-fashioned solution.

You will no doubt benefit from it as I have; and I am not sure how I got along without it before I purchased it at Books Canada. A terrifically superb guide that I highly recommend.

Susan A. Jarzen, Volunteer in Paleobiology, Canadian Museum of Nature, Ottawa, Ontario, CANADA.

Life above the jungle floor

By Donald Perry. 1986. Don Perro Press, San José, Costa Rica. 170 pp. Paperback. ISBN 0-67154454-3.

Strap on your climbing harness and prepare for a basic introduction into a fledging field of science–treetop canopy research. This book deals with the joys of exploration and captures the sheer excitement of examining a new and relatively unexplored frontier–the

rainforest canopy. Set in Costa Rica, the unbridled enthusiasm of a fledgling graduate student for exploring the unknown sets the tone for much of what follows.

Accessing the canopy (beginning at 10 metres and extending up some 17 stories) is not a comfortable venture for most humans. The author uses his experiences to theorize about why this is so. Although these points are in many cases anecdotal, they are food for thought. Anyone "fortunate" enough to have been suspended in a tree some 17 stories off the ground realizes that the information presented in the chapter "Extinction of the dinosaurs" is meaningful.

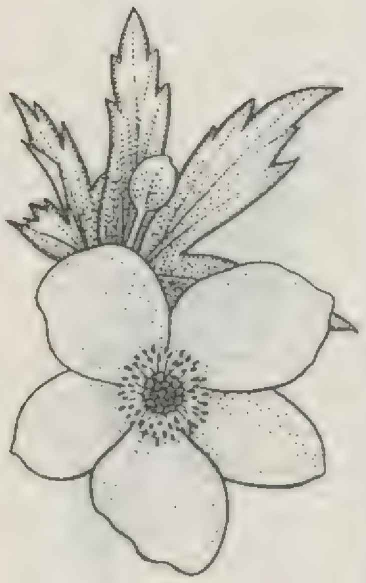
A particularly strong point of this book is the author's ability to expose the reader to a myriad of real life adventures encountered when exploring canopy life. Imagine lowering yourself down into the hollow of a tree only to be surrounded by a myriad of creatures that send chills down most people's spines–bats, scorpions, gnats, amblypygids, and large cockroaches.

Suspension high above the ground presents an array of logistical problems when it comes to recording biological information. The author does an excellent job in recounting his personal experiences in this regard, and nicely mixes in several interesting natural history points (and pictures) that help one understand the floral and faunal complexity of these unique arboreal communities.

There is a strong message throughout this book and it is encapsulated in the closing chapter titled "A New World Ecology." Simply stated, tropical forests of the world are under seige, and given the weight of burgeoning human populations, the outlook is somewhat bleak. This, of course, is what we now refer to as the global biodiversity crisis, which correlates directly to continued habitat loss in many regions of the world. How one meets the challenge of dealing with the biodiversity crisis is complicated. However, a sense of respect, wonderment, and love of exploration of our natural systems so deftly mentioned throughout this book seems like a good starting point to meet this challenge.

NOTE: At present, new canopy projects have been initiated in many areas of the world. In Canada, the first fixed canopy access system located on Vancouver Island is currently being used to explore the complex arboreal community in 700-year-old Sitka spruce groves.

Neville N. Winchester, Department of Biology, University of Victoria, Victoria, B.C., CANADA



Systematics, ecology, and the biodiversity crisis

Niles Eldredge, editor. Columbia University Press, New York. July, 1992. 220 pp. + ix. Hard cover. $40.00 (cl). ISBN 0-231-07528-6.

This volume is a result of a symposium entitled "The Role of Museums in the Biodiversity Crisis" held at the American Museum of Natural History (AMNH) in March, 1990. As natural history museums have long been the principal reservoirs of research in systematics, and 10 of the 13 papers are written by museum researchers (including 7 from the AMNH alone), it is not surprising that the collection of papers is a strong endorsement for the role of systematics in addressing the present biodiversity crisis.

The goal of the volume, according to Eldredge, is twofold: to enhance the general appreciation of the importance of systematics and to raise the consciousness of systematists on the importance of their participation in meeting the challenge of the crisis in loss of biodiversity. In this, the volume succeeds. However, as we might expect, there is no consensus or unifying theoretical approach. None of the systematists, ecologists, or paleontologists who contributed to the volume give us a plan to educate politicians and other decision-makers to ensure closer links that ultimately might affect decisions and policy changes. However, there are pertinent examples from the Americas and elsewhere in the world, from both marine and terrestrial environments, to drive the point home that mitigation of the present rapid loss of biodiversity can't be accomplished in isolation from only a detailed knowledge of the relationships between organisms.

Each of the 13 chapters is complete with its own references. Eldredge, in the introduction and first chapter, sets out a general theoretical background to the problem of separate approaches by ecological and evolutionary biologists. Platnick discusses boreal and megafauna biases in commonly-accepted "patterns" of biodiversity; Tattersall uses Madagascar primates to illustrate differences between systematic and ecological measures of diversity; and Stevens discusses resource competition and species richness in the tropics. Cracraft and Sepkoski, in separate chapters, introduce geological time and mass extinctions in their perspectives on patterns of biodiversity, a refreshing reminder to those who assume the present crisis to be the first time the metaphorical sky has fallen. Novacek and Stiassny give overviews, respectively, on the contributions of systematics and phytogenetic analysis as tools, and Barrowclough and Winston each discuss the relationship between systematics and conservation biology. Taboada presents a case study from Cuba on the conservation of diversity within socioeconomic and political contexts. The specific contributions of living collections such as zoos and botanical gardens are discussed by Flesness, and Vanzolini looks at the role of natural history museums in third world countries in the study, monitoring, and conservation of biodiversity.

The volume demonstrates the relationship between ecology and systematics in the shared concerns of the origin, maintenance, and particularly, the loss of biodiversity. Loss of biodiversity implies extirpation or extinction. Habitat alteration, the principal mechanism of extinction, is studied by ecologists, who use as a diversity measure the number of species represented by local populations within an ecosystem. The measure of extinction to a systematist is also one of diversity, but defined as reduction in the number of species within a monophyletic taxon. Clearly, input from both disciplines is essential, but neither approach is sufficient in itself to address this complex global problem, particularly from the perspective of causality.

There is cause for hope here–for the understanding of the role of museums and their systematists in addressing the biodiversity crisis, for the advancement of knowledge through collaborative research to understand the underlying mechanisms that regulate the biosphere, and for the value of examining the present crisis from the perspective of geological time. There is need for ecologists, conservation biologists, systematists, economists, and decision-makers to enter together into constructive discussions aimed at assessment and priority setting. This book, with its concluding index, will be a useful backgrounder for that informed dialogue.

Stephen L. Cumbaa, Research, Paleobiology, Canadian Museum of Nature, Ottawa, Ontario, CANADA.

Systematics of economically important marine algae: A Canadian perspective

By C.J. Bird and J.P. van der Meer. 1993. Canadian Journal of Botany 71(3): 361-369.

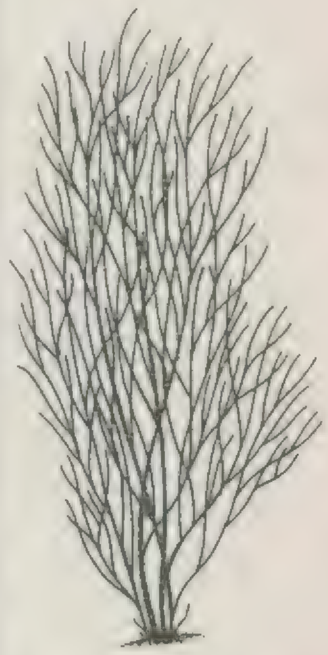
Marine algae of economic importance encompass species of positive value, such as seaweeds harvested for food or hydrocolloid extractives, and species with negative effect, such as toxic phytoplankton or nuisance macrophytes. Only a small part of the global algal resource is obtained in Canada, and the overall benefit to the nation's economy is relatively minor, but there is potential for further development of useful species.

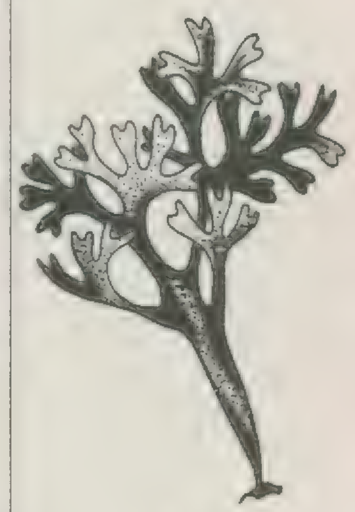
On the other hand, the negative effects of toxic microalgae are increasing and take the form of losses to the shellfish fishery and aquaculture industry, and the costly requirment of toxicity-testing and phytoplankton monitoring services. The effective use of valuable algae, or defense against undesirable ones, must be attended by sound taxonomy to ensure that algae of interest are correctly identified and recognizable. However, the algae present particular problems to systematists. The major problem is the variety of life histories, which may involve independent and conspicuous dissimilar life phases. In addition, many algae are highly variable physically (but not necessarily, genetically) in response to environment, which is often insufficiently appreciated. The converse situation also exists, in that morphologically similar species are sometimes regarded as a single entity. Algal taxonomists should strive to determine which variations are genetic and therefore taxonomically significant. To illustrate these points, we review recent taxonomic studies on some algal genera of present or potential economic importance in Canada. [Authors' abstract].

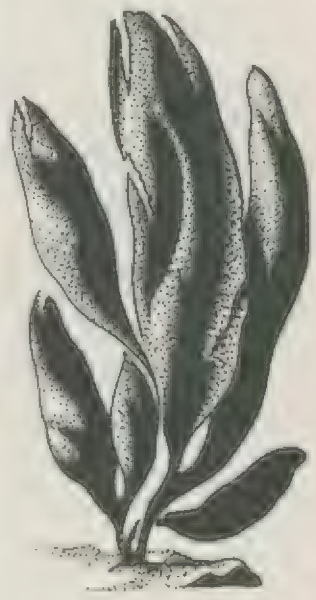
Forest management strategies that account for short-term and long-term consequences

By Donald Ludwig. 1993. Canadian Journal of Forest Research 23(4): 563-572.

This paper presents a method to calculate the long-term effects of forest management decisions for an age-structured forest (as opposed to even-age forests or plantations). The calculation of such effects is required to assess the sustainability and, indeed, the rationality of forest-harvesting strategies. The primary focus of this paper is "falldown," i.e. the decrease in timber available for harvesting due to lack of large old trees. The largest net-discounted economic returns are obtained by rapid harvesting (mining) of old growth. However, in the longer term, the consequences of a decrease in harvest volume on local communities can be devastating. How







can this conflict between short-term and long-term interests be reconciled? I consider a variety of strategies that vary in their sensitivity to the effects of falldown, and I present some pilot calculations that illustrate a method to weigh the consequences of following these strategies. [Author's abstract].

The importance of mountain alder on the growth, nutrition, and survival of black spruce and Sitka spruce in an afforested heathland near Mobile, Newfoundland.

By André J. Hudson. 1993. Canadian Journal of Forestry Research 23(4): 743-748.

This paper provides evidence that monoculture tree plantations may be less productive than mixed plantings. The natural invasion of mountain alder (*Alnus crispa* (Ait.) Pursh) into monoculture plantations of black spruce (*Picea mariana* (Mill.) B.S.P.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) afforded an opportunity to assess the effects of mountain alder on soils, and thus, their effect on the growth, nutrient status, and survival of spruce in northeastern Newfoundland.

The plantations were established on ploughed *Kalmia-Vaccinium* heath in 1968-1969. Significant increases in the growth of spruce were associated with the presence of high densities of mountain alder in the two plantations studied. The increases began three to six years after the invasion and establishment of mountain alder. Estimated nitrogen contributions to each plantation from mountain alder leaf litter fall were approximately 50 kg per hectare each year. Spruce foliage nitrogen content was 10-15% higher in high density mountain alder (HD-alder) plots than in low-density mountain alder (LD-alder) plots, but other foliar nutrient concentrations were low and possibly deficient in the HD-alder plots. Development of a litter fall/humus layer was observed in HD-alder plots but not in LD-alder plots; however, B-horizon nitrogen soil values did not differ significantly between HD-alder and LD-alder plots. The mountain alder invasion did not reduce the densities (stems per hectare) of spruce. Additional studies on the autecology or the ecology of a single species such as *Alnus* spp. native to Newfoundland, and on alder-spruce interactions are recommended to further the development of an adequate ecological basis for heathland and peatland afforestation in the region. [Author's abstract].

The Run of the River

by Mark Hume, New Star Books, 2504 York Avenue, Vancouver, B.C. V6K 1E3, 215 pp., $14.95 (paperback), ISBN 0-921586-00-0.

I read this book while camped by a remote lake and while paddling and fishing along wild and pristine reaches of the Little Rancheria River in the northern part of British Columbia. It seemed to be an appropriate place to read Mark Hume's book.

This book deals with issues and conditions in eleven British Columbia rivers. In it the reader visits, one way or another, the Columbia, Ingenika, Nechako, Thompson, Deadman, Adams and Salmon, Stikine, Tatshenshini, Khutzeymateen, Cowichan, and Megin Rivers. In these "visits" we are introduced to water-use conflicts involving hydroelectric development, mining, agriculture, or forestry. The issues and concerns are presented, in many cases, through vignettes about people who love the rivers or through the comments of such people. The writing is rich with vivid descriptions of wild fish, rivers, lakes, and mountains.

I have a few criticisms: The book appears to have been written in a hurry for there are errors in it, such as the incorrect location of the Nechako River on the first page map, misspelling of people's names, and minor errors of fact. In some places biological situations are oversimplified. These faults are real, but they do not detract from the powerful message that Hume has for us, nor do they detract from the seriousness of the issues that he presents.

Hume has written with moving eloquence about the tragic cost of river development to the aboriginal people in the Cheslatta and Ingenika areas. He tells us of losses of salmon runs in the Columbia and Salmon Rivers. He tells us of conflicts that exist and of forestry and mining operations that threaten the quality of other rivers. He tells us that we still have some choices but some options are already gone. Hume loves rivers; he appreciates their values and he celebrates their beauty. He raises questions about which we should all be thinking.

Gordon F. Hartman, Fisheries Research & Education Services, 1217 Rose Ann Drive, Nanaimo, BC, V9T 3Z4, CANADA

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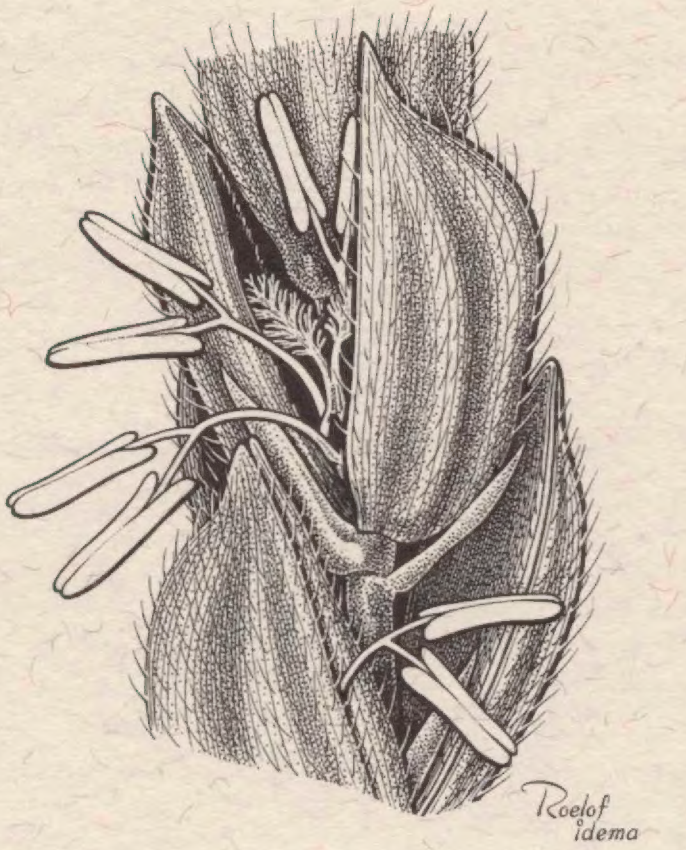

Oryza sativa

Woe unto them that join house to house, that lay field to field,
till there be no place, that they may be placed alone in the midst of the earth!

Isaiah 5, 8

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